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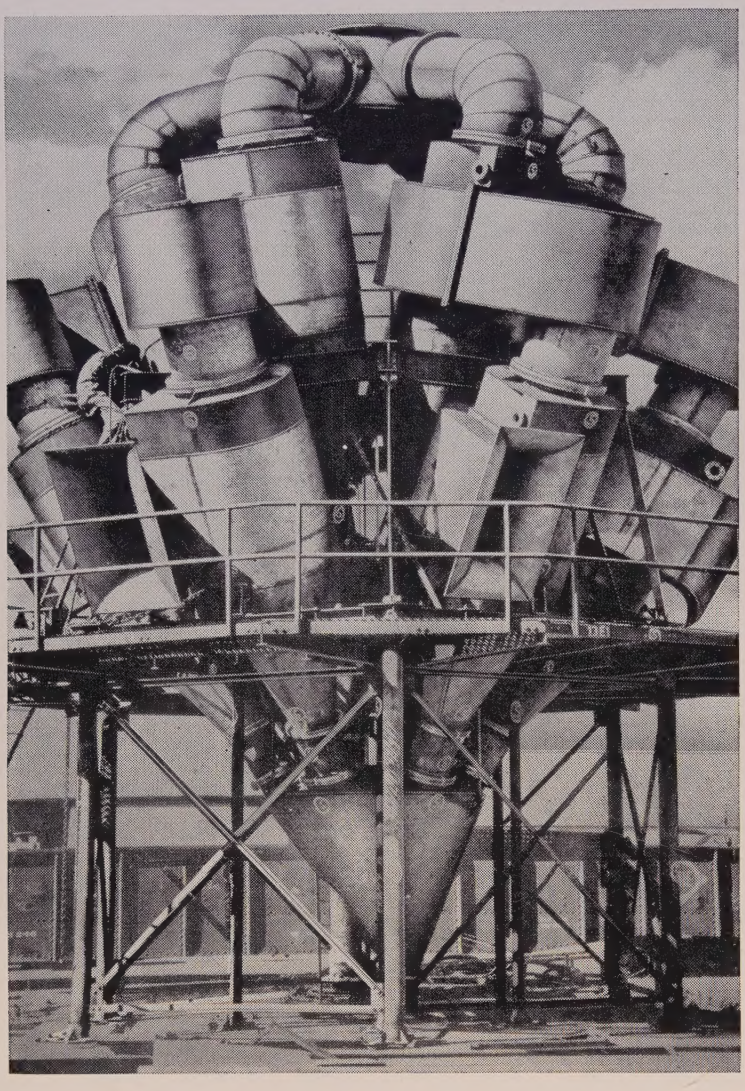
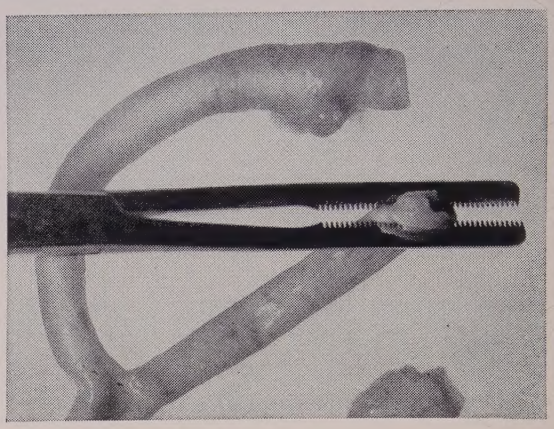
ILLINOIS TECHNOGRAPH

Only STEEL can do so many jobs so well



Visitor from Outer Space? No, despite its strange, other-worldly appearance, this is no product of extra-terrestrial intelligence, no flying saucer. It's a perfectly practical, very down-to-earth catalyst collector in a large petroleum refinery. Noteworthy, however, is the extensive use of USS Stainless Steel in its fabrication . . . to provide corrosion resistance combined with great strength.



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Published eight times during the year (October, November, December, January, February, March, April and May) by the Illini Publishing Company. Entered as second class matter, October 30, 1920, at the post office at Urbana, Illinois, under the Act of March 3, 1879. Office 213 Engineering Hall, Urbana, Illinois. Subscriptions $1.50 per year. Single copy 25 cents. Reprint rights reserved by *The Illinois Technograph.* Publisher's Representative—Littell Murray-Barnhill, 605 North Michigan Avenue, Chicago 11, Ill. 101 Park Avenue, New York 17, New York.

THE ILLINOIS TECHNOGRAPH

volume 69 **number 7**

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our cover

The Network Analyzer in the Electrical Engineering Department is used to analyze all electrical circuits of any magnitude or complexity. The cover shows the artist's conception of the various control panels and banks of resistors, inductors, and capacitors.

our frontispiece

With Chicago's famed Soldier Field forming a backdrop, a Caterpillar 10-ton tractor with an early bulldozer model worked on part of the construction of the Stadium in 1924.

Evolution of the Crawler

50 YEARS ON TRACKS

•

by Don Arnold
E.E. '55

•

This year marks the fiftieth anniversary of the world's first successful track type tractor. It was in 1904 that the first practical crawler was successfully tested in California. This unit is the forefather of some 340,000 crawlers which are now working in many fields.

The conception of the crawler came out of the need of a unit with compact power that would not be bogged down by the soft soil of the delta lands of California. As a result of the immense farms, some as large as 100,000 acres, combines became larger and larger. Benjamin Holt of the Holt Manufacturing Company in 1893 made a behemoth with a 50 foot cut. This machine was pulled by 40 horses and was operated by 6 men. In these delta areas, horses sank deeply in the soft soil and the need for more compact power was apparent.

In the first years of the Twentieth Century, Holt attacked the problem from the angle of a track-laying tractor. This idea of a machine that laid and picked up its own base was hundreds of years old, but the principle had never been successfully applied to a commercial vehicle. The result was the world's first practical track-type tractor—tested Thanksgiving Day, Nov. 24, 1904.

Only eight of these steamers were built. In 1906, the gasoline motor replaced the steamer, and the tractor came into demand for loggers and builders, road construction, and hauling freight.

Immediate demand for the evolutionary machine called for expansion and the purchase of a new plant in Peoria in 1909. By the middle of 1910, there were 65 employees at the Peoria plants.

During World War I, almost 10,000 of Holt's Caterpillar tractors were licensed for wartime use. Further, his crawler was the inspiration to General Ernest D. Swinton, inventor of the tank.

After the war, the government distributed most of the tractors to the various state highway departments. This year, 1919, marked an all time peak of 26 million farm work animals and truly the beginning of the end for "Old Dobbin."

In 1925 the Holt and Best Caterpillars combined to form Caterpillar Tractor Company centered in Peoria, Illinois. The years following the merger saw rapid development and an increase in new working tools for the tractor—namely rubber tired wagons and scrapers, bulldozers, rippers, pipe layers, front-end shovels, and a variety of agricultural machinery.

Meanwhile, in the late 1920s, company engineers were thinking in terms of a new power diesel. Over a million dollars was spent in research which preceded the first Caterpillar diesel tractor in 1931.

Even in the throes of the depression, reception was overwhelming. In April, 1932, one of the new tractors went to work on an Oregon ranch. Forty-six days later, the tractor finished its continuous run. It had traveled 3,500 miles and plowed 6800 acres (150 acres daily) —at an average fuel consumption of only 5.73 cents per acre! This machine dubbed "Old Tusko" by its present owners, is still operating on a ranch nearly twenty years later.

News of the unprecedented diesel economy—the fact that these new engines burned low cost fuel and less of it, cutting 50 to 80% from present fuel costs —spread like wildfire. Because of the great demand, the company soon entered the diesel engine field.

In 1933, the company sold more diesels than tractors although there were more models of gasoline tractors. By 1936, Caterpillar employment had soared to 10,000—3,000 above the pre-depression peak, and the total U. S. diesel production rose from 100,000HP in 1932 to 2,000,000HP in 1937.

Now approximately 2,200,000 square

The first practical track-type tractor is shown above as it was being tested near Stockton, Cal. It was originated by Benjamin Holt in 1904.

feet have been added to the main plant in Peoria. The new diesel engine division, covering half of this area, is considered the most modern in the world. In 1951, plans were announced to build an additional half-million square feet onto the Joliet plant and to build a 370,000 square feet plant in York, Pa. Again, on June 2, 1953, the company announced a new $45 million expansion program including a new 700,000 square feet plant at Decatur.

Today, Caterpillar produces 12 diesel power units and marine engines in sizes up to 500HP and 12 electric sets with outputs up to 315KW. In all, there are 93 different Caterpillar products produced by some 26,000 employees, 21,000 of which are located at Peoria.

To honor the crawler on its 50th birthday, Caterpillar is conducting a commemorative program with the theme, "50 Years on Tracks." W. K. Cox, sales promotion manager at Caterpillar, points out, "We believe this is a significant milepost because the crawler has played such an important role in the progress of our nation both peace and war. During this half century, it has been instrumental in the development of modern methods of constructoin, logging, mining, and oil and agriculture fields."

Today in its fiftieth year, on civil or military projects, the crawler is busier and better than before. And it can look back on an outstanding record of accomplishment in the progress of the last 50 years.

History of Caterpillar

edited by Don F. Kesler, E.E. '56

It was in 1859—when the Gold Rush was still headlines and oil newly discovered in Pennsylvania—that young Best, 21, punched a four-head oxen team across the Great Plains. Bad luck hounded him for the following 10 years as he tried gold mining, hunting and sawmilling in the Great Northwest, and failed at each in turn.

In 1869, he took charge of his brother's ranch near Marysville, California. At the time, grain was hauled from the Best fields to Marysville for cleaning, the charge being three dollars per ton. Best wondered, "Why not bring the cleaner to the grain instead?"

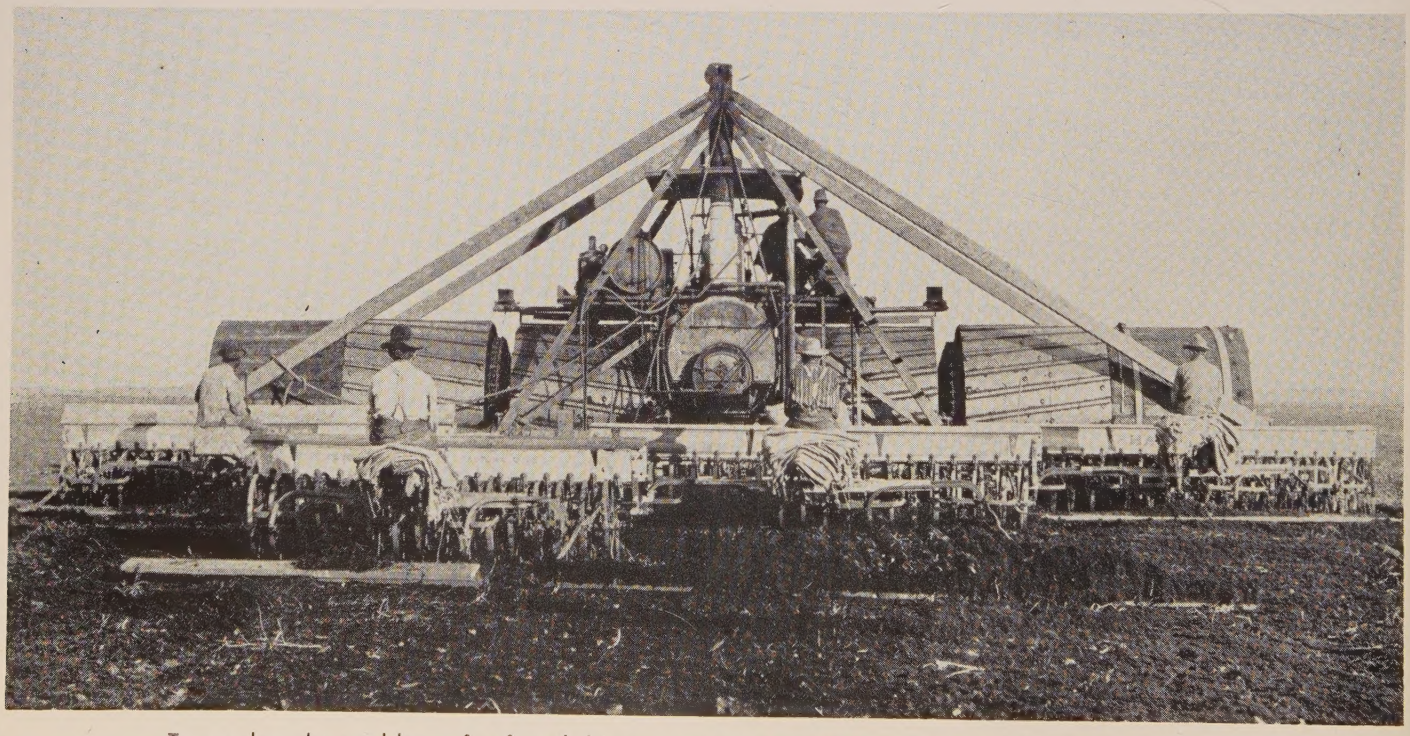
During the winter of 1869-1870, he built three cleaners which proved instantly successful. Such was the demand for these machines that Best opened a factory for their manufacture in Marysville.

For some years, several larger California growers had been attaching headers and threshers to Best equipment in an attempt to field-process wheat from standing grain to sack. Best had dreamed of building his own combined harvester in the early seventies; it was no surprise to his friends when he began experimenting in 1884 and produced and sold his first machine in 1885.

In the meantime, the Holt brothers were making similar progress in San Francisco and Stockton, California. Charles Holt left Concord, New Hampshire, in 1863, sailing for Panama on a tramp steamer. The young pioneer, age 20, plodded across the Isthmus and headed for San Francisco. Here, he first worked at odd jobs . . . later teaching school in Hydesville, California, by day, and keeping books in the local general store by night.

In 1869, having saved $700, Holt returned to San Francisco and established C. H. Holt & Company, "Importers of hardwood lumber." He was soon joined by brothers, William and A. Frank Holt. In 1873, the fast growing firm founded an East Coast factory in Concord, the family home, for manufacture of wheels, bodies and other wagon parts. Benjamin Holt, only 24 and already the ablest engineer and mechanic of the family, helped run the business.

During the following decade, it became apparent that wood products of the East did not receive proper seasoning for the hot, dry western climate. Wheels shrank, warped and fell apart under the merciless heat and sand. Charles Holt decided to manufacture wheels and other articles for wagon assembly on the West Coast in a location where hardwoods could season



To combat the problem of soft soil this special steam powered unit was built by the Holt Manufacturing Company

properly. The Stockton Wheel Company was the result, established in that city in 1883. Benjamin Holt came west to superintend the new works.

The Concord factory was disposed of three years later. By this time, Charles and Ben were the only brothers in the business, Charles managing the old San Francisco firm, now called "Holt Bros. Company."

Products of the Stockton plant were monuments to Ben Holt's inventive versatility. The 1880s saw wagons, carts, wheels, farm implements, blacksmith and building supplies not to mention railroad cars and street cars, both horse-drawn and electric! In 1886, the first "Holt Bros. Link & V-Belt Combined Harvester" appeared on the agricultural scene.

Combines of that day were ground driven; that is, internal machinery was geared or belted to one of the ground contact wheels. To get around uneven operation as horses speeded or slowed, Best patented an ingenious blast fan governor which maintained constant blast pressure against cleaner elements irrespective of the variable speed of horse travel. In 1889, he sold his first steam powered combined harvester.

Ben Holt perfected the sidehill harvester in 1891. Now for the first time, the combine could go almost anywhere a horse could go—and still operate efficiently. This development made profitable grain farming a reality on hundreds of thousands of sloping, untilled acres across the Pacific Northwest. One of the sidehill machines was shipped to Australia in 1894.

The later years of the nineteenth century witnessed great interest in land reclamation in the Sacramento and San Joaquin River Valleys. Some of the farms in the area covered as much as 100,000 acres. Here also was delta farmland stretching mile after mile without a tree or rock—a promise of wealth to any who could plant or harvest. (Old timers spin yarns of ranches so huge you could start plowing and then harvest on the return trip.) Horses was not the answer to the need for more usable power in the soft deltas.

Was steam the answer? Best and Holt led the West Coast in production of steam traction engines during the "Big Steam Era," 1890-1910. Best sold his first steamer in February, 1889. Holt followed with "Old Betsy" in 1890, an engine that incorporated his famous steering clutches (patented the following year), and which operated summer and winter for the subsequent quarter-century. With the steam traction engines, daily harvest totals occasionally ran as high as 125 acres and 4,000 bushels.

But, as capacity increased weight climbed accordingly, many steamers eclipsing the 20-ton mark. And as weight increased, wheels mired even deeper into the soft delta soil. To combat this tendency and provide increased bearing area, both companies added larger and larger wheels. Holt Manufacturing Company built a behemoth with three six-foot-wide wheels on either side, each being 7'6" in diameter. Overall tractor width was 45'8"!

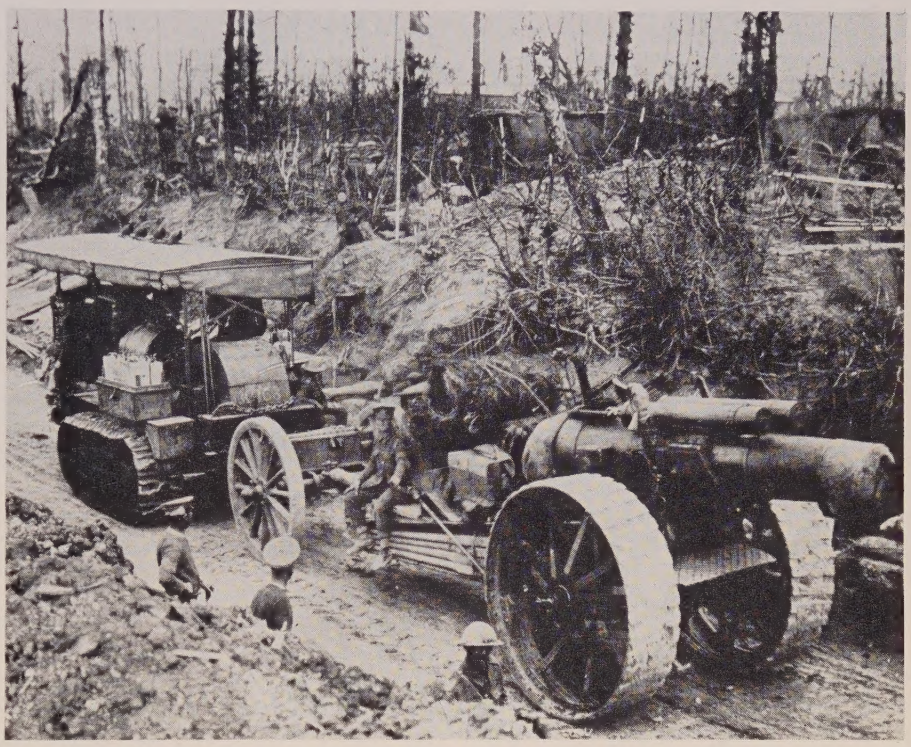
In the first years of the Twentieth Century, Benjamin Holt began to approach the traction problem from a different angle. The need for a prime mover of larger ground contact area, yet with high maneuverability, led him to the idea of a track-laying tractor.

Holt ingeniously combined known ideas and created new ones, mounting a pair of rough tracks on a steam engine from which wheels had been removed. The crawler, a 40HP machine, would pull four gangs of plows two inches deeper than the Holt 60HP wheel model could pull three gangs!

In 1906, steam power was replaced by gasoline, and the new crawler became more versatile and cheaper to operate. Though its first market was the farm, it eventually became a time-saving tool for loggers and builders. In those days when motor trucking and road construction were still in their infancy, the crawler was much in demand for overland freighting as well. Later, as it helped construct the roads that made short haul freighting the exclusive province of the truck, it literally built itself out of a market.

Immediate demand for the revolutionary machine called for expansion of Stockton facilities and, in 1909, purchase of a new plant in Peoria, Illinois.

Business began to climb the following year, primarily because of foreign orders. Casteran Hermanos, Holt's Argentine dealer, succeeded so well in popularizing the track-type tractor that a standing order of 15 crawlers per month was placed with the Peoria factory. Dr. Leo Steiner of Hungary became Holt's first European dealer in 1912 and immediately placed orders for 40 machines.



Thousands of crawlers were used during World War I to haul personnel, artillery and supplies across the battlefields of two continents. Here a Caterpillar "75" pulls a huge howitzer across battle terrain.

The year 1908 marked the sale of Best facilities to Holt and the end of intense Best-Holt rivalry. Not for long, however, 1910, C. L. Best, son of Daniel, organized the C. L. Best Gas Traction Co., at Elmhurst, California, for the manufacture of wheel-type tractors. After three years, he marketed his first crawler, the Best "75," and competition between Best and Holt interests became keener than ever before.

In 1919, th Best "Sixty" was brought out, introducing anti-friction roller bearings in transmission and track roller frame.

In the ensuing five years, both Holt and Best sales organizations were widely expanded, products becoming well known all over the U. S. and in many foreign countries. The track-type tractor

led the giant road building boom of this period.

In 1925, the Holt and Best organizations combined to form Caterpillar Tractor Co., and, because of geographical advantages, manufacturing was centered at Peoria, Illinois. C. L. Best was named chairman of the board; the merger was engineered by H. H. Fair, West Coast financier and present board chairman. Caterpillar executive offices were moved from San Leandro to Peoria in 1930.

The years immediately following the merger saw rapid development, not only in the crawler tractor itself, but also in the equipment designed to work with it. New tools appeared in front, in back and on top of the crawler—rubber-tired wagons and scrapers, bulldozers, rippers, pipe layers, front-end shovels and a great variety of agricultural machinery.

After the merger, Caterpillar devoted more and more engineering and manufacturing to the needs of the construction man and road builder. To round out product line and further strengthen its background of road building experience, Caterpillar Tractor Co., acquired the Russell Grader Manufacturing Company of Minneapolis in 1928. Russell, organized in 1903, had helped pioneer the development of elevating graders, blade graders, self-propelled motor patrols, scrapers and portable crushers.

At first, Caterpillar continued the Russell Motor Patrol, a machine designed for mounting on a crawler tractor base. In 1931, production of this model was stopped. In its place, Caterpillar offered the auto patrol, integrating important features of previous graders, but introducing a product completely redesigned. Placing the engine behind the operator was one of many innovations. The machine took on a new look with engine up out of the dirt, more weight over driving wheels, mechanical power controls and rigid axle drive.

The auto patrol created new markets and methods for construction men and caused demand for a heavier, more powerful machine capable of full-fledged construction work. The versatile Caterpillar Motor Grader, first marketed in 1938, was the answer.

News of unprecedented diesel economy—the fact that these new engines burned low-cost fuel and less of it, cutting 50 to 80% from fuel bills—spread like wildfire. Because of the great demand, the company soon entered the diesel engine field, supplying diesel powered tractors and road machinery to the agricultural, construction, logging, industrial and governmental markets; and diesel engines to sawmills, cotton gins, rock crushers, irrigation pumps, industrial plants and manufacturers of power driven equipment such as excavators, compressors, drill rigs and locomotives. Later, special marine diesels and diesel electric sets were added to the fast-growing line.

All over the world, the new diesel crawler marshaled a successful struggle to send forth earthmoving costs plummeting . . . on such well known undertakings as the Prince Albert Canal, Zuider Zee, Grand Coulee and Fort Peck dams, Pennsylvania Turnpike and "Big Inch" Pipeline.

Holt got away from the bulky steam engine in 1906 when he built the first gasoline powered crawler.

The beginning of World War II brought a new need for tractors and road machinery to build airports, military roads and war plants; to clear land and haul supplies; to hit the beach with the first waves of amphibious landings . . . a need for engines and electric sets to furnish light and power for advance bases, isolated locations and bombed-out areas.

In addition, the company was asked to produce tank transmissions, howitzer carriages, shells and other war materials. A subsidiary, the Caterpillar Military Engine Company, was formed to operate a plant in Decatur, Illinois, for manufacture or radial diesel tank engines. However, wartime need for standard Caterpillar products was so acute that both Decatur and Peoria abandoned special production and concentrated on the pre-war line.

As in World War I, the Caterpillar track-type tractor became a familiar sight on World War II Allied fighting fronts all over the world. Military construction men found it an indispensable tool, particularly for the rapid-schedule airfield and road construction needs of Pacific island warfare.

After the war a huge expansion program was immediately launched to handle increased demand and build post-war additions to the company line—bulldozers, scrapers, rippers, wagons and power controls. A giant new plant in Joliet, Illinois, now manufactures this equipment.

On December 19, 1951, Mr. Neumiller announced acquisition of the Trackson Company of Milwaukee. The well-known Wisconsin firm is operated as a wholly-owned subsidiary and continues to manufacture front-end shovels and side-boom pipe layers as auxiliary equipment for Caterpillar Diesel Tractors. Trackson's two plants occupy about 150,000 square feet of manufacturing and office space and employ approximately 600 people.

In total, capacity to manufacture machines and parts has been more than doubled since January 1, 1946—at a cost of over $150 million. Dollar sales volume for 1953 ($433.8 million) was almost 3½ times that of 1946.

The entire Caterpillar parts operation is geared to quick delivery of quality parts. Under the company's unusual "No Orphans" policy, parts are regularly supplied for machines still operating in the field after more than 30 years' service.

On June 2, 1953, the company announced a $45 million expansion program, including extensive retooling and rearrangement at present plants and a new 700,000 square foot plant. The site at Decatur, Illinois, was selected the following month. The latter will be devoted to the manufacture of motor graders and industrial wheel tractors. Construction will begin early in 1954 and the plant is expected to be operating late the following year.

In 1954, its fiftieth year of significant accomplishment, the track-type tractor is busier and better than ever before. The world's number one earthmover, it is a dynamic symbol of industrial progress.

With the crawler tractor as central tool, price of the common excavation yard on U. S. highways has dropped 25% since 1900—in the face of greatly increased personnel and product costs. Because of the crawler, logs are coming out of the woods quicker and cheaper . . . crops are growing on hills and marginal lands where none grew before . . . pipelines are linking oil and gas fields to cities in an ever expanding web.

Now we find track-type tractors working on civilian and military roads . . . clearing streets and saving lives when winter comes calling . . . building dams, airports, and levees . . . tilling and terracing our farmland . . . working in deserts and forests and icelands . . . erecting bridges and buildings . . . powering crushers, cotton gins, shrimp boats and public utilities. Wherever there is construction progress or pioneering there will be found a crawler tractor.

There Is No Waste Here!

RE-REFINED OIL

by Paul W. Erb, Chem. E. '54

Reprinted from Northwestern Engineer

Change your oil? Change your oil? CHANGE YOUR OIL? Every one or two thousand miles you change the oil in your car. Under adverse conditions you may change it more often. Or perhaps you conveniently forget and don't change it quite so often. In any case there are thousands upon thousands of quarts of oil—dirty, grimy, diluted, weakened oil—removed from cars, trucks, buses, trains, airplanes, and machinery, every day of the week. What happens to all this oil? Surely it must have some value.

Much of this oil may be discarded—wasted—but sometimes it is salvaged in some manner. It may be reclaimed. That is, impurities such as solid carbon, gasoline, road dust, and water are removed by filtration and low heat treatment. But more and more, the oil is being re-refined. In re-refining all impurities, including oxidation products, dissolved in the oil, are removed by a refining process similar in many respects to that given virgin oil.

A used oil properly treated is as good as or better than new oil. According to W. S. Boynton of the Wright Aeronautical Corporation, "Re-refined oil may be used over and over again and is usually preferred to new oil. It has more body, the volume consumed is not so great as with new oil, and it has better lasting and holding qualities." Re-refining of used oil is based on the fact that oil does not wear out or break down to any great extent. Dr. Winslow Herschel, associate physicist, Bureau of Standards, states, "Oils do not wear out mechanically; they do not wear out in the sense of wear in a rope, in which the length of fiber has been shortened and which cannot again be made as useful as when new." When used in an engine, oil becomes adulterated with suspended solid impurities and dissolved liquid impurities. The removal of these impurities by correct re-refining methods renders the oil fit for use again.

Re-refining of oil is becoming big business. As early as World War I it was tested and proved, and now re-refining of crankcase drainings is a practice accepted by thousands of commercial oil users. In a recent year almost eighty million gallons of high grade lube oil were re-refined and put back into use. Most of the oil re-refining is done as "custom jobs" for industries, airlines, railroads, trucking concerns, bus and cab companies, public utility companies, and the like. The oil is collected, treated separately, and returned to the company. About seventy-five percent of the re-refiners' business is done with commercial users. Collecting used oil for re-refining and sale at filling stations is a highly localized, difficult, and rather high cost method of operation.

It has proved profitable for certain major oil users to do their own re-refining. Some of the major airlines like American Airlines and Pan American Airways operate their own re-refineries. Others, like Eastern Airlines, send their oil to a commercial re-refiner, since commercial refiners are able to restore oil to any required specifications. A major customer of the commercial oil re-refiners is the United States Air Force, which in a recent year sent out 2,700,000 gallons of used oil for reprocessing. This operation reportedly saved the taxpayers $600,000, and today the Air Force gets top grade oil for approximately 20 cents a gallon. During the recent war, re-refining returning 1,000,000 gallons of crankcase drainage a month to top grade aircraft engine oil specifications.

Re-refined, or "further refined" oil, as it may more properly be called, is actually "triple-refined." It is originally refined from the crude; it is further "refined" in the crankcase of the car, where the remaining sulfur is oxidized and the weaker hydrocarbon molecules are broken down; and it receives its third refining in the re-refining process, where these impurities are removed along with other accumulations. For the refiner of crude oil to carry his refining process to the extent to which it is carried in the crankcase of a car would be economically unfeasible.

The re-refining of used oil generally follows the pattern of either the steam distillation process or the newer, lower temperature, vacuum distillation process, both of which are used by the petroleum industry to refine crude oil. The steps in both processes are essentially the same, except for the temperature and pressure at which distillation and fractionation occur. Basically the steps may be broken down as shown below: removal of water and solid particles by dehydration and settling; sulfuric acid treatment to precipitate gums, grease, and other matter; alkaline treatment to neutralize acid compounds; water wash to remove soaps formed in neutralization; mixing with special clays such as Fuller's Earth to bleach the oil and absorb certain impurities; distillation to drive off light ends, moisture, and other volatiles; filtering to remove clay and other solids; and blending to desired specifications and the use of additives.

In the re-refining process 75 to 90 per cent of the drainings to be processed are usually recaptured as good oil. The oil may be re-refined many times. Some oil in Greyhound buses has been lubricating pistons for 200,000 miles. The process, while removing the impurities, usually removes all traces of additives put in by the refiner of the crude oil. In most cases only fifty per cent of the original amount of additives has to be added to the re-refine doil to produce an oil of the same quality.

Aside from the prevalent misconception that oil wears out, re-refiners have other false ideas to overcome. The confusion existing between reclaimed and re-refined oil and the tendency to identify the two as one has hurt the re-refiners' business. Reclaiming methods are incomplete and inadequate, and are often based solely on the removal of visible solids. Various methods of filtration, such as through earths, sands, sawdust, papers, rags, fibers, porous blocks, and the use of centrifuges have been tried to obtain this removal. Since many of the harmful impurities found in used oils such as moisture, diluents, tars, and resins can not be properly extracted by filtration, reclaimed oils have not been able to live up to the impossible claims made for them, resulting in prejudice against re-refined oil. With proper re-refining these aluterants and diluents are eliminated, giving the used oil the body, viscosity, viscosity index, and other properities of new oil. The viscosity index is a measure of the degree of change of viscosity with temperature changes, a high index indicating a small amount of variance. A good quality light or medium weight oil will have a viscosity index of 90 or above.

Another problem faced by the re-refiner, which is of more concern to the average motorist than to the commercial user, is a disbelief by the buying public in the re-refiner's ability to produce an oil of consistent quality. With the commercial used he does not face this problem, since the oil he receives from the is usually of a standard quality to begin with, has generally been used in a similar manner each time, and is most likely removed after a definite

period of service. The re-refiner then treats each batch separately as it arrives. Furthermore, the commercial user sets specifications and usually has a means of periodically testing the re-refined oil to see that these specification are met.

However, the re-refined oil that the motorist buys at the local filling station has had varied backgrounds. It was picked from a garage pit where all types of oil were dumped, where the best and the poorest grades have been intimately mixed. It is hard to believe that out of this hodge-podge the re-refiner can produce an oil day after day with consistent qaulity. Yet that is exactly what he does.

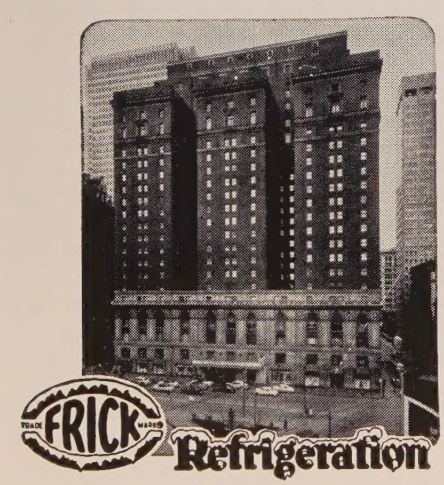
Although crude oil may be either an asphalt base or a paraffin base oil, many oils are a mixture of the two and the main difference between brands and the various grades of new oil is the degree to which refining has been carried out and the amount of additives used. The refining process that takes place in the crankcase of the car tends to equalize the differences in the degree of original refining, and the re-refining process removes all the additives. This means that the re-refiner can depend upon a fairly consistent product and can count on making up any differences by the amount of additives that he uses. Also, the re-refiner has found that he can depend upon collecting from the filling stations a mixture of oils having a fairly constant content. Thus he is able to standardize his process to some degree.

The above facts still give the motorist no assurance that he can depend upon consistent quality from the same re-refiner, since the re-refiner is able to produce oils of all grades. But so is the refiner of crude oil. Yet we have come to rely upon his ability and integrity, and we choose our oil by brand and grade without any doubts. Being relatively new in the field, the re-refiner has not yet been able to build up a reputation. Realizing this, the Association of Petroleum Re-Refiners, with headquarters in Washington, D. C., has prepared a list of specifications, which must be met by the re-refiner before he can carry the seal of approval of the Association on his product. Because of the exacting specifications thus met, a re-refined oil carrying the seal of the Association of Petroleum Re-Refiners is probably more consistent in quality than new oil from a certain refinery. The association is also willing to answer questions in regard to individual re-refiners.

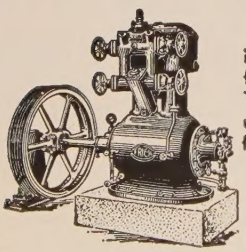
Outside of its advantages to the immediate consumer, re-refined oil serves us in other ways. Re-refining of oil is a means of conserving one of our most important natural resources—crude oil. Estimates on savings by using re-refined oil have shown that aircraft and engine manufacturers save about 60-70 per cent of their total oil requirements while airlines save less than 20 per cent. The reason for this is that because of frequent drainings after their numerous tests, manufacturers discard more oil than they burn.

Crankcase drainings are all too often dumped into city sewers, left to be collected by city sanitation facilities, or poured into rivers and streams. The U. S. Fish and Wildlife Service and numerous state and local authorities have found that dumping of used oils causes serious river and stream pollution with resulting injury to fish and other wildlife, and hazards to and interference with navigation. Before re-refiners located in the Washington, D. C., area collected most of the city's oil waste, it cost the city tens of thousands of dollars annually to collect and dispose of these used oils. Now the taxpayers need no longer finance this operation.

It is not hard to see why re-refined oil is becoming more and more accepted by the average consumer. An estimate of the saving to the U. S. public already afforded by the collection of used oils by re-refiners amounts to approximately $5,000,000 per year. With all these accomplishments to its credit, re-refined oil is fast making a name for itself in the petroleum industry.



Provides Five Services for Hotel William Penn



These include air conditioning, cooling drinking water, refrigeration of foods, freezer service, and making ice. This magnificent Pittsburgh hotel has used Frick equipment since 1936, and finds it both efficient and dependable.

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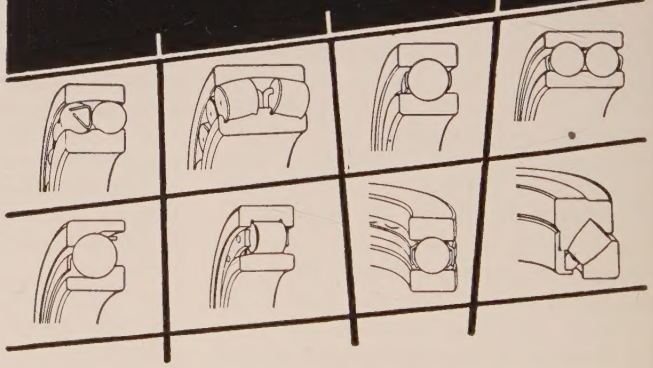

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LEE de FOREST

by Don F. Kesler, E. E. '56

Wireless telegraph, wireless telephone, radio, audion, amplifiers, and sound on film movies were only a few of Lee de Forest's inventions. The patent office issued the rights of an inventor to Lee de Forest over 200 times.

After receiving his doctor's degree from Yale in 1899, Lee went to work in the experimental laboratory of Western Electric. At night he continued the work of his thesis, "Reflection of Hertzian Waves from the Ends of Parallel Wires," pursuing the lines of wireless telegraph. He searched physics journals and conducted the existing experiments of the Marconi wireless telegraph.

In April, 1899, *Wiedemann's Annalen*, in an article by Aschkinass he found a brief description of a newly discovered detector. A piece of tinfoil was laid upon a piece of glass and cut with a razor. When a battery and telephone receiver were connected to the terminals and a drop of water was placed over the gap, a sound could be heard when a spark generated electric waves in the vicinity. This was exactly what he was looking for. Work began on the "Responder," de Forest's first detector.

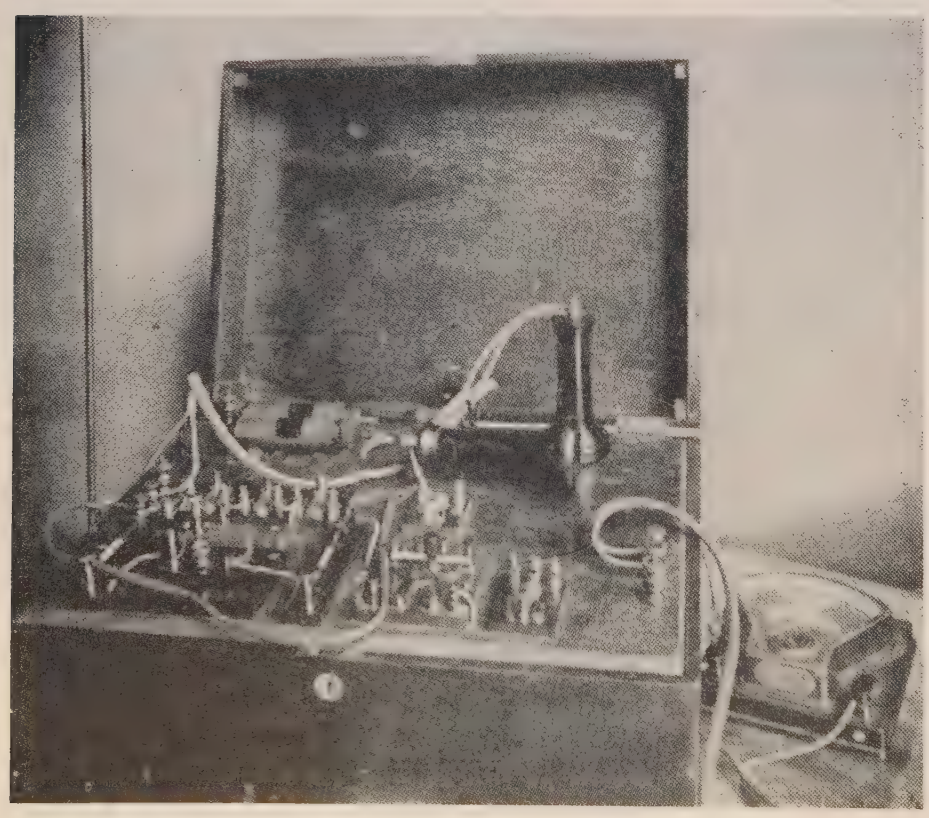
Professor Johnson, owner of the Johnson Pneumatic Heat-Control System, came to Chicago and offered de Forest a job with his company. He accepted the offer at fifteen dollars a week. Immediately he began working on Johnson's perfectly impractical system of receiving wireless messages. After several weeks of waiting, hour on hour, for the signal to come through, Lee was thoroughly disgusted with the Johnson detector. One day he brought the Responder to his end of the work. Within an hour he was steadily picking up the signal.

Lee decided to give more time to his responder, so he quit his job and began working half time for *Western Electrician*.

After a lot more work and research, a company was formed. In 1902 the American De Forest Wireless Telegraph Company was thriving, A new alternating-current transmitter was developed with amazing success. The company began building sets and some were sold to the Navy and others to the public.

During the Russo-Japanese war, the *London Times* continually scooped the other newspapers by days. Lionel James equipped a small dispatch boat with wireless. Once during his adventure his boat was being approached by the Russian cruiser, Bayan. Seeing the danger, he telegraphed the *Times* to notify the British Consul if he was not heard of within three hours. When the Russians boarded and saw the message he had sent and received, they immediately let him go.

Lee de Forest, the first disc jockey, at one of his broadcasts.



Early Responder, the wireless telegraph and radio receiver

Thursday, April 6, 1906, wireless had been sent across the Atlantic. With little change other than more transmitter power, wireless had been sent across the ocean.

The greatest advance in radio yet today was the invention of the Audion. The three electrode vacuum tube was the first amplification in history. The Navy rejected the use of Audions in their recievers, so this stopped the development of this marvel for a year.

Late in 1906, Lee de Forest designed the carbon arc transmitter, thus wireless telephone was here. He began transmitting and asked all telegraph operators who might hear it to telephone his laboratory, so that he might know that he was heard. (All the wireless telegraph receivers were using telephone earphones to head the sound. They were exactly the same as the radio receivers to be built later.) Again attempts were made and records were broken for the maximum distance for radio broadcasts.

Lee de Forest's dream was realized when the Metropolitan Opera went on the air. In the winter of 1909, Lee went to Andreas Dippel, the assistant director, who possessed vision and enthusiasm for the project. Together they put a transmitter in the attic and brought Caruso to the masses.

In 1912 work was begun on an amplifier. After three weeks of building

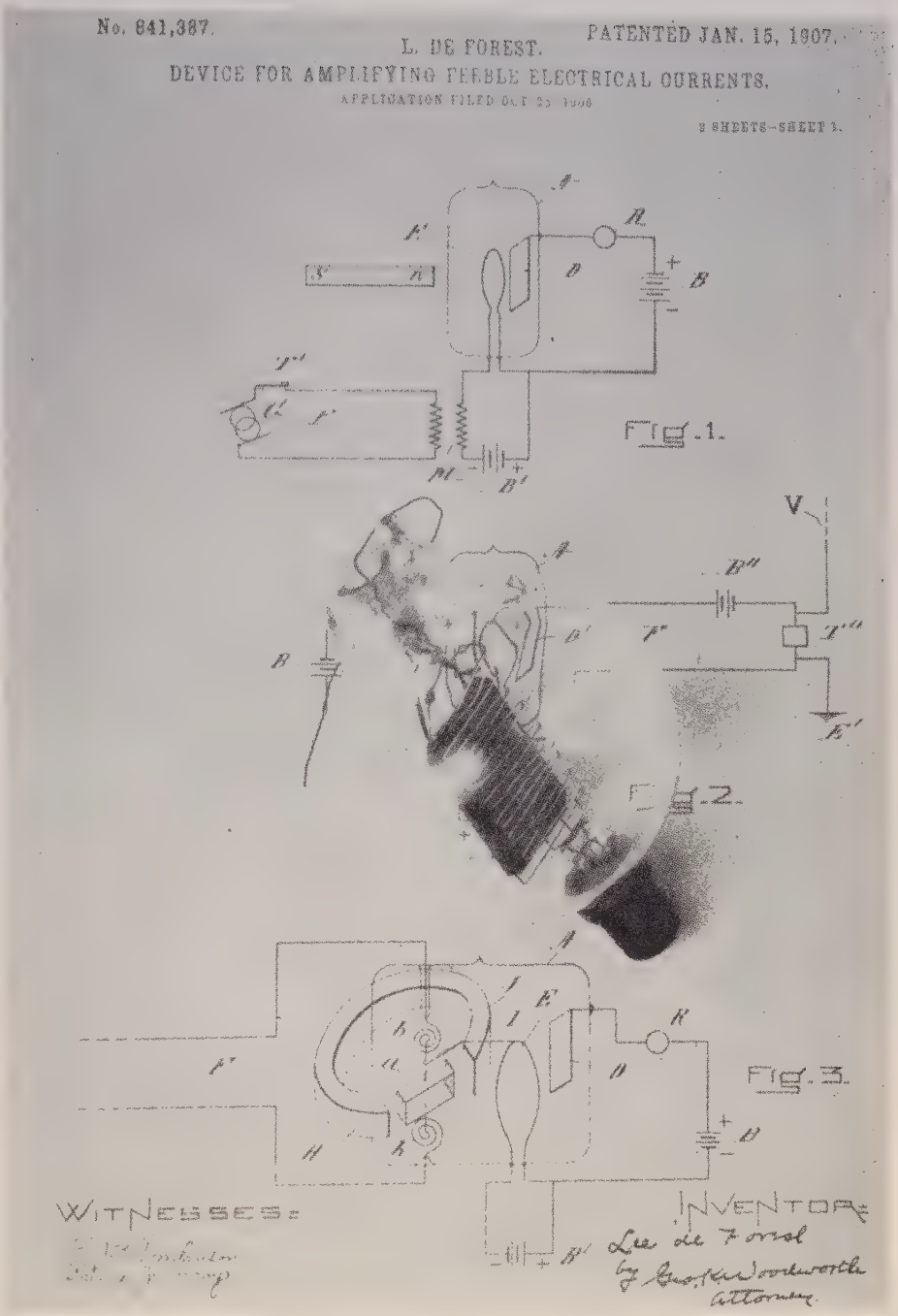
and rebuilding Audion's and Audion circuits, a small, but comforting amount of amplification was gained. He connected the plate of one Audion through a transformer to the grid of another and found he could amplify electrical signals. By connecting them in series of two or three, he could get a larger gain. He kept working until the threshold of hearing was two blocks from his "loudspeaker." Demonstrations were made for American Telephone and Telegraph Company, and Western Electric. At one time during the experiment he had only one Audion, and hooked the plate to the grid to try to make the tube do the job of two. In trying to obtain self-amplification, he got self-regenration, or in other words, self-oscillation. Thus we have regenerative radios and transmitters.

A. T. and T., through a go-between agent bought the wire rights for seven Audion patents for $50,000. Actually the company had voted to go as high as half a million dollars for the patents. They had bought the rights to make amplifiers and use them for telephone and telegraph for only $50,000.

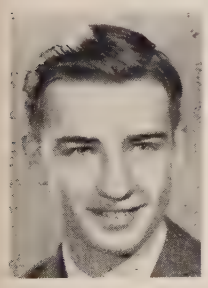
The Uultra-Audion circuit was discovered by accident. The B battery was connected directly to the plate, with the radio-frenquency inductance and variable condenser in shunt, connected across the grid and plate electrodes of the tube. The Ultra-Audion circuit was used for several years after that.

The Marconi Company brought suit against the De Forest Company on the grounds of infringing upon the Fleming valve patent. All the patents were made to cover as much ground as possible, but the Marconi Company was trying to stretch the Fleming valve patent to cover amplification. (It was proven in the Supreme Court in 1943 that the Fleming valve was merely a rectifier and no amplification was made.) The De Forest Company filed counter suit because they were infringing upon the three-electrode Audion tube patent.

When Marconi admitted the validity of the Audion patents, the Honorable



The Audion Tube patent is considered one of the most important issued



Don Kesler is a sophomore in Electrical Engineering. Besides his school work and the Technograph, he works on meters in the Instruments Laboratory in the Electrical Engineering Building. Don is a permanent resident of Urbana.

Judge Julius Mayer said, ". . . . these parties came into court and in forthright and manly fashion admitted their sins. They should not therefore be punished for so doing. Injunction is denied!" The court then ruled that the De Forest Company had infringed upon the Fleming valve patent. Immediately they appealed the case, and two years later, they lost the appeal. As a result of the case the radio tube industry was a hopeless mess until the Fleming valve patents ran out in 1922.

In 1921, Lee de Forest found new worlds to conquer. Edison had synchronized phonograph and movies to attain "talkies," but he had poor success. Earlier de Forest had tried it with steel telegraphone wire. Now he thought it could be done with light, photographed on the film. He made his first talking movie in June, 1921. The first theater preview of sound films came two years later with Eddie Cantor in monologue and Lillian Powell in her graceful bubble dance and lovely music. Photofilm, sound on film movies, was hard to sell until "Don Juan" was produced in 1926. Then the battle for the patent rights begun.

During the greater portion of his work, Lee de Forest was struggling hard to get the finances to produce his inventions. His greatest invention, the electron tube, has brought over a billion dollars to the patent owner. Of this he received less than a million dollars, less than one tenth of one per cent. Less than one per cent of radio listeners and television viewers know who made it possible for them to listen to the Metropolitan Opera in their home.

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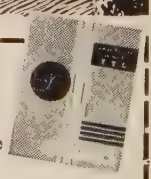

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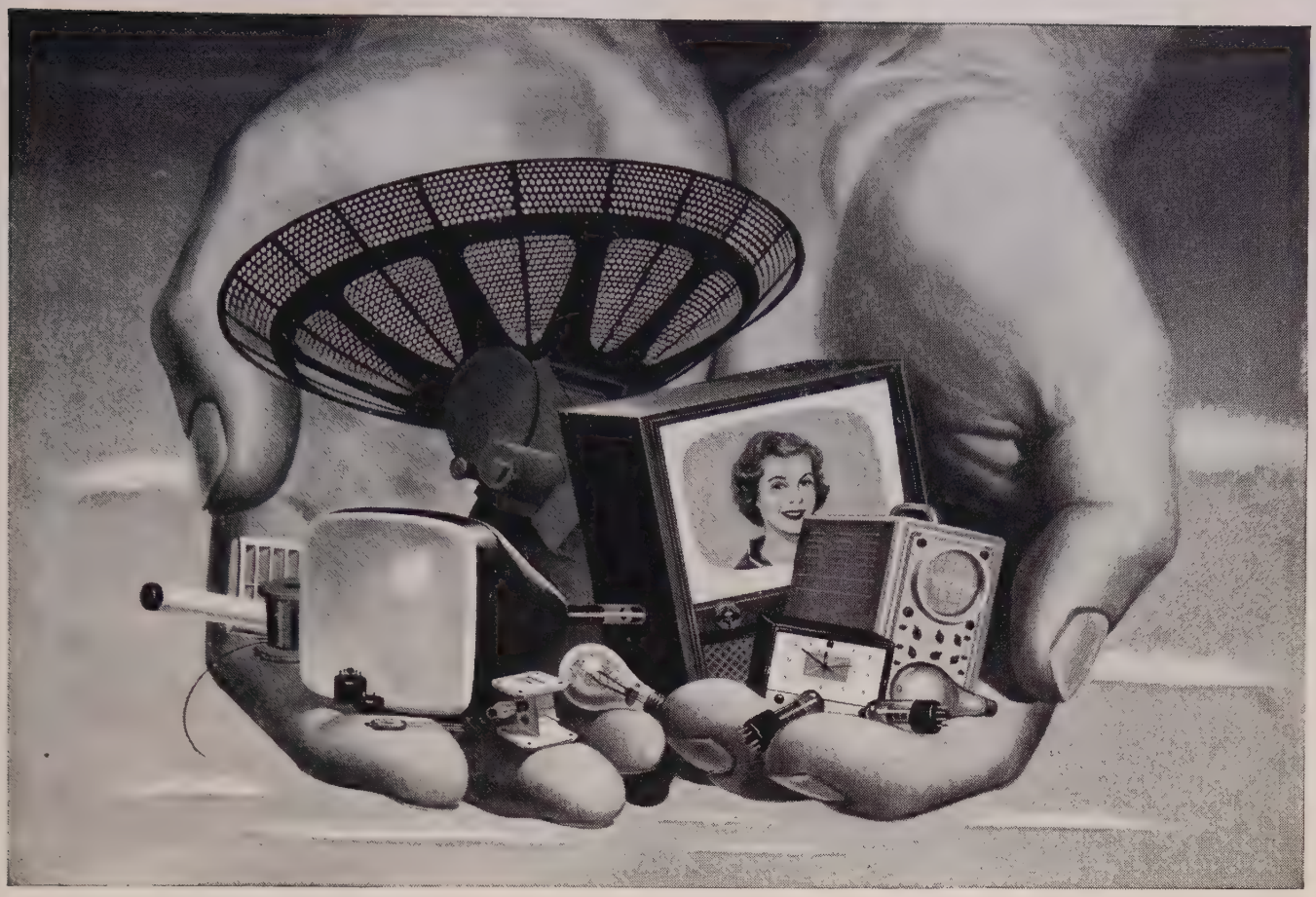

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MULTIPLYING ELECTRONS

edited by Don F. Kesler, E.E. '56

For more than forty years, science has searched for a practical way of converting radiations from the atom's nucleus to electricity. Though research is far from completed, successful operation of the atomic battery represents a major breakthrough toward that goal.

The conversion of nuclear energy into electricity is achieved by an experimental atomic battery, powered by a minute quantity of a long-life strontium-90 radioactive isotope obtained as a by-product of atomic reactor operation. The electric current derived from this unique atomic battery exceeds by many times all previous results attained in attempts to generate usable electricity directly from radioactive material.

This big stride has been achieved by coupling the battery's radioactive source to a transistor-like wafer, which instantaneously releases some 200,000 electrons for each electron it receives from the radioactive material.

This development, though still in a pioneer stage, may prove to be the beginning of a new and basic chapter in man's efforts to utilize some of the enormous untapped energies within the nucleus of the atom for peaceful purposes and for the enrichment of human life rather than its destruction. Although it is still too soon to know all the uses to which this direct conversion of nuclear energy might be put, the prospect of an entirely different kind of power source is a particularly exciting one for the electronics industry.

Perhaps as startling an advance as any in connection with the atomic battery is the fact that a single rapidly moving, electron, emitted from the radioactive atom, produces no less than 200,000 slower electrons in the bombarded semi-conductor. It is this extraordinary multiplication in the number of available electrons which promises to make the atomic battery a usuable device of practical significance.

Progress in increasing the efficiency of the atomic battery has been rapid during the past few months and is expected to continue. Results to date indicate the possibilities of producing thimble-size, atomic batteries. When these experimental batteries are developed to a commercial stag, they can supply power for radio receivers and other kinds of electronic appartus, without replenishment or attention for at least twenty years.

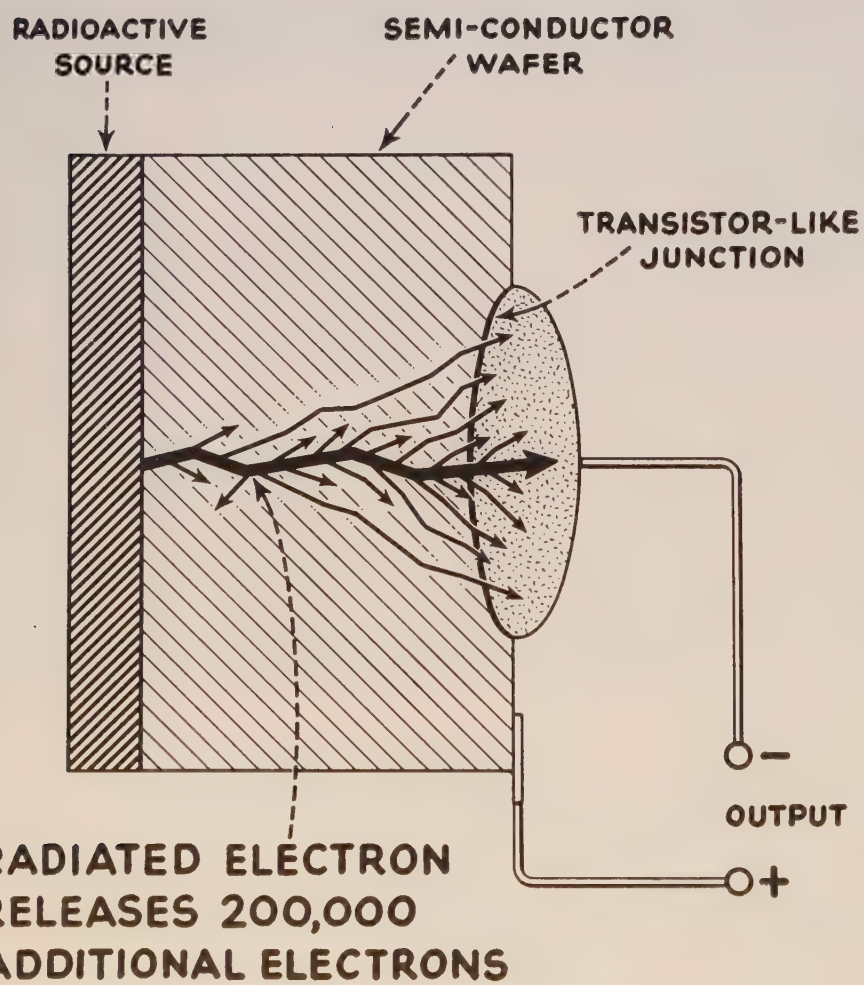
The atomic battery is likely to be applied first to miniature devices such as portable and pocket-size radio receivers, hearing-aids, signal control, and similar devices that require reliable power sources with great length of service.

As we learn how to produce atomic batteries with more power than is obtained from present experimental models, it may be possible to use them for operating portable short-range transmitters for radio telegraph and telephone communication and radio beacons for navigation by air or by sea.

Of great importance is the fact that such atomic batteries will be highly compatible with future equipment using transistors. Both the battery and the transistor have the potential advantages of compactness, ruggedness and long life.

Until recently, radioactive battery devices produced, at best, a billionth of a watt of power under conditions suitable for transistor operation. Today, with

EXPERIMENTAL RCA ATOMIC BATTERY



Simplified cross-section view of experimental Atomic Battery. Radioactive source, which is strontium-90 in present version, radiates billions of electrons (beta particles) per second for many years.

Magnified model of the two basic elements of experimental Atomic Battery, which makes it possible to convert atomic energy directly into small but usable quantities of electrical energy.

only a small amount of radioactive material, single atomic battery provides a millionth of a watt—enough to run a transistor audio oscillator circuit. This gives a tone that is audible twenty feet away. With more radioactive material, a number of these "one-cell" devices could be stacked in a single case to produce a larger output.

Strontium-90 is not now obtainable in completely purified form, that is, other fission products have not been entirely separated from it. Since some of the unwanted radioactive materials are emitters of gamma radiation, shielding is necessary in the laboratory device.

However, strontium-90 in purified form, emits only beta particles which, for the quantities that would be used in a small atomic battery, does not raise problems of shielding.

Strontium-90 costs about 50 cents for a thousandth of a curie today. The radioactive material for today's atomic battery would cost $25.00. A wide demand for the material in atomic batteries and other applications would warrant quantity processing of the material. This, it has been estimated, might bring its price down as low as two-tenths of a cent for a thousandth of a curie, or 10 cents for a battery.

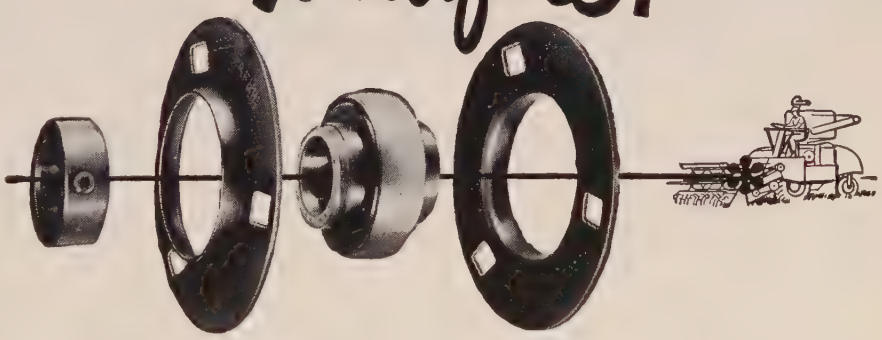
An aspect of atomic batteries that has yet to be determined accurately is the extent of the effect of the beta radiation on the crystal wafer. It is known that the crystal structure of many substances is gradually damaged by bombarding electrons. Further research is in progress to minimize these effects so as to make them neglibile for the structures used in the atomic battery.

This new and distinctive approach to the harnessing of the atom's energy for peaceful purposes is most timely. This is a big step toward the atomic peace proposals President Eisenhower laid before the United Nations on last December 8th. These proposals for international development of the peaceful uses of the atom are now being discussed between nations and are much in the public mind.

No one can look far enough ahead to see all the ways in which a new principle or scientific method will find practical application. Some of these, however, we can anticipate, such as providing small quantities of power at low voltage for various kinds of electronic devices where extreme compactness, ruggedness and long life without attention are important factors. But when we deal with something as basic as capturing the energy of the atom and turning it directly into electricity, the first practical applications may not foretell the full scope and range of its future usefulness.

The history of science and invention presents many notable examples of scientific progress of which the atomic battery is the latest. When Michael Faraday first produced an electric current it was with a relatively simple device: a copper disk rotated between the ends of a magnet. Faraday—120 years ago—did not visualize the future of his invention, yet, today, the huge power generators at Niagara and the Hoover Dam operate on the same basic principle of Faraday's discovery. Who knows what we can operate with atomic batteries?

The idea that caught like *Wildfire!*



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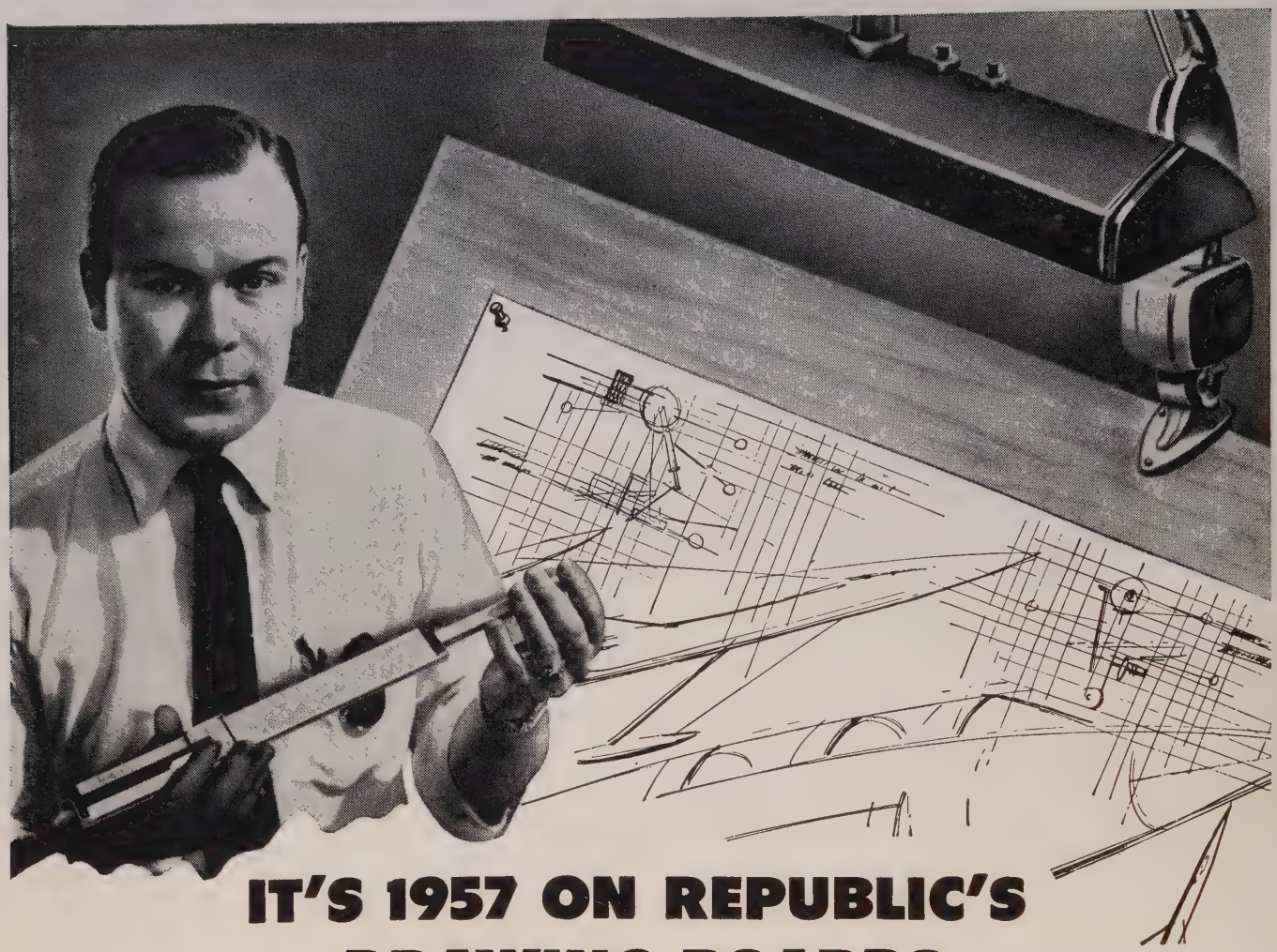

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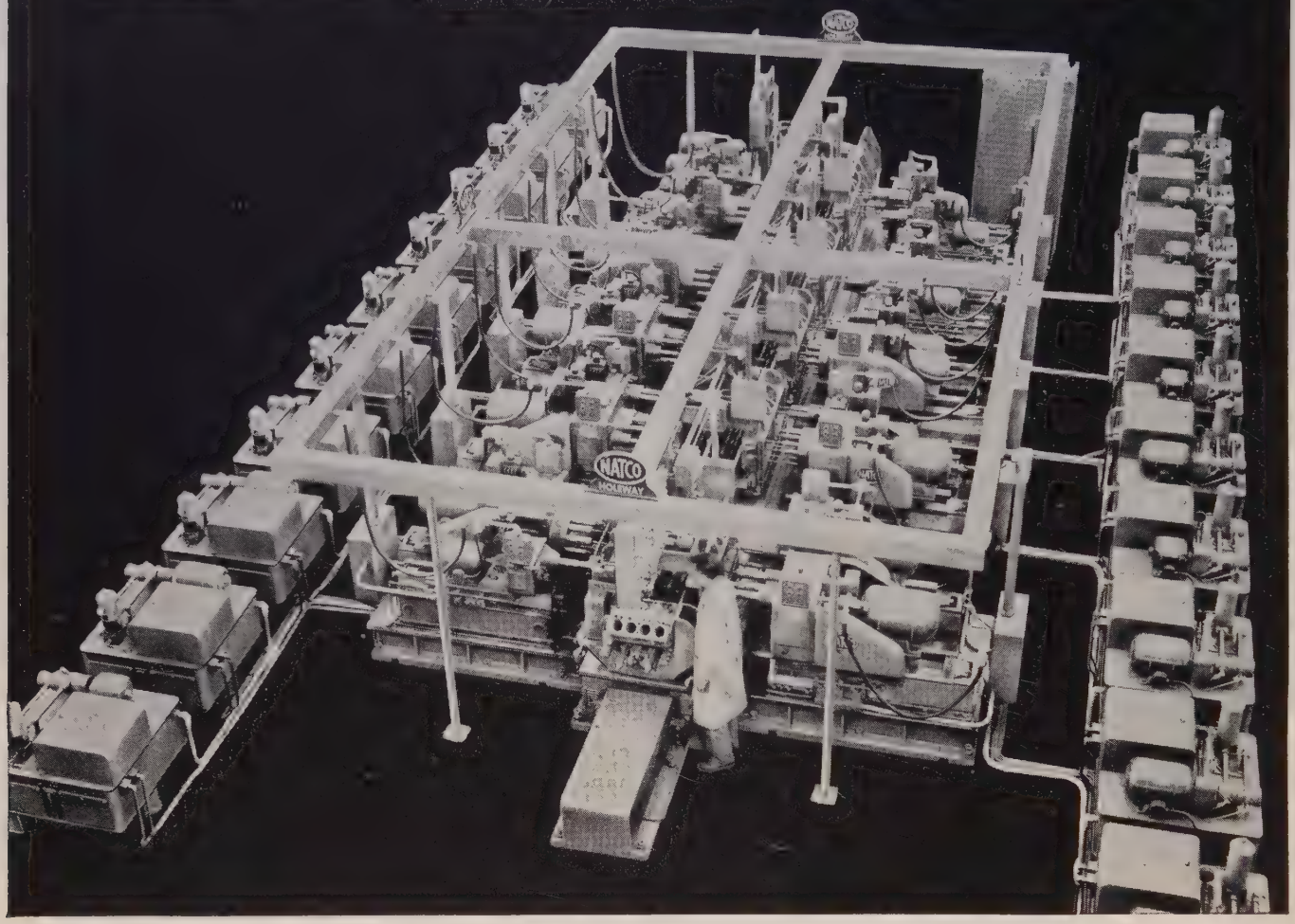

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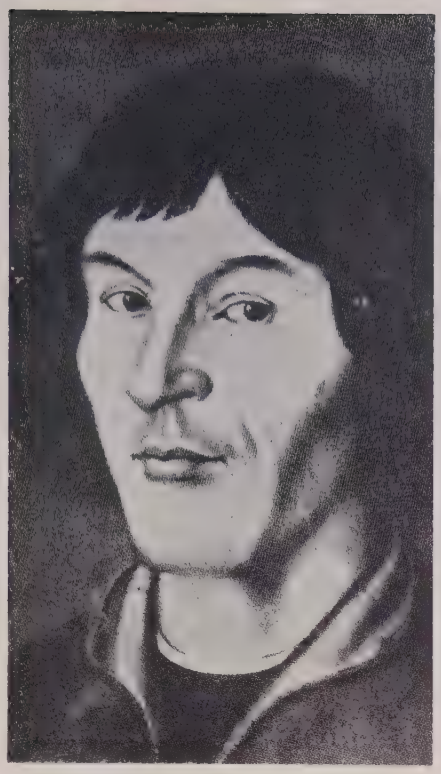
NICHOLAUS COPERNICUS

by Donna Rudig
Eng. Phy. '57



NICKOLAUS COPERNICUS

Mathematician, theologian, astronomer, and medical man—Niklas Koppernigk, son of a Polish wholesale trader and German housewife, was all of these. He shook the foundation of the early Rennaissance Period's belief in the Ptolemic Universe and planted the seeds for our modern version of the solar system and its movement.

In 1946, when he was 23 years of age, Koppernigk journeyed to Bologna to study Canon Law and to follow the lectures of Domenica Maria Novara, the astronomist. The next year, the Jubilee year in Rome, he was elected Canon. Also during this time he taught in Rome as a professor of mathematics; but in 1501 he gained leave of absence so that he could continue his academic career and entered medical school at Padua. He left Padua in 1505; but meanwhile, in 1503, he had received a doctor's degree in Canon Law at Ferrara.

Returning to Poland, Koppernigk resided at the Epicopal Palace in Hilsberg as his uncle's physician until the bishop's death on March 29, 1512. He then went to Frauenburg where he acted as chapter representative under harrassing administrative and political conditions. Also he was commissary of the diocese of Ermeland. Much of his time he spent in giving medical service to the poor although he was often demanded by the rich. In 1522 he devised a plan to reform the currency and presented it before the Diet of Graudeny.

Ever since the time of his professorship in mathematics at Rome, Koppernigk had become interested in astronomy and, through observations and calculations, became convinced that the Ptolemy theory of the earth being the center of the Universe was wrong. According to his heliocentric theory, Koppernigk believed that the earth revolved about the sun once a year, the earth rotated every 24 hours on its axis, the sun was the stationary center of the Universe, the planets revolved in uniform circles about the sun, and that the earth rotated from west to east. Since these ideas were so revolutionary to the ones of that time, and he could offer no valid proof for them, Koppernigk hesitated to declare them publically. However, these ideas circulated among his friends and fellow astronomers by means of letters and word of mouth.

About 1530, when he was sure of his theories, Koppernigk prepared a manuscript, *Commentarioulus (Little Commentary)*, to give to his friends. Although Cardinal Schönberg gave Koppernigk a formal demand to publish his theories, it was not until 1540 that friends finally persuaded him to consent to do so. George J. Rheticus printed his book, *De Revolutionibus Arbium Colestrium (Concerning the Revolutions of the Heavenly Bodies)* in 1543.

Toward the end of 1542, Koppernigk was struck by apoplexy and paralysis. The first copy of his book barely reached Fraunburg in time to be placed on his death bed, saving him the disappointment of knowing that the book had been marred by a preface stating that all the material in it was purely hypothetical. Koppernigk died on May 24, 1543.

In later years Johannes Kepler described Koppernigk as "Copernicus, vir maximo ingenio, et quod in hoc exercitio magni, momenti est, animo liber" (a very approximate translation would be "Copernicus, man great in size, and whom in this great practice, is influential, a book in his mind.")

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From the Phone to

THE COVER

by Dave Templeton

F.A.A. '55

"Hello, Dave. This is Howie Hadler," said the voice on the other end of the phone. "I've got the assignments and articles for next month's issue."

"Just a second while I get a sheet of paper and a pencil. Okay, shoot."

And this is the way a Technograph cover and the spot drawings for some of the articles start for the magazine you are now reading. Howie Hadler, our associate editor, gives me a call, tells me what the articles in the next issue are, and if they don't have anything specific to feature, it's up to this individual to pick the one that will lend itself to the best design.

Being in art school, most of the engineering subjects don't have half the meaning or familiarity to me as they do to the engineer. In a way, this is an advantage, because if the cover is to appeal to someone who isn't an engineer but is a little interested in the subject, I feel that to throw him a complicated photograph would make him shy away from the magazine . . . which is the first thing we don't want to do.

But yet, this is an engineering magazine. Consequently, I can't draw a cover from what I know about the subject. Because, believe me, as I mentioned before, my knowledge is very little. And if there's anything more annoying to a person looking at a picture, it's one that has obviously been drawn without very much of an idea what the subject is all about.

So, the next step in this phone-to-finished-drawing story is either a trip to the library or a talk to the person directly connected with the article. It's at either of these sources that I make sketches and talk to someone who can tell me just how the subject which I am drawing effects you and me . . . the citizen . . . the laymen (if you aren't an engineer). All of this goes into a sketch pad which is generally never out of my possession. This is because at times I can sit and try to get an idea and it doesn't come. But suddenly it pops into this thing I laughingly call a brain and I might be in a class or even walking down the street at the time. An idea can pop out of the mind as easily as it pops in. So, it's best to get the idea down quickly before it's forgotten.

The many-time-mentioned idea is on layout and a way to tie the engineering end of the illustration up with a familiar scene . . . the aforesaid way the subject effects Mr. and Mrs. Citizen.

After making some preliminary sketches and finally working it down to almost a finished drawing, I start on the final drawing itself. This is done on a piece of 15″x20″ illustration board (but the drawing is actually 12¾″ square which is reduced to magazine size by the engraver). The entire drawing is done in blue pencil because there is no danger of the photoengraving apparatus picking up black marks left by a too heavily pressed graphite pencil. What I want printed is finally inked in with India black ink. The blue pencil marks, which I don't ink in, can be left on the drawing without fear of being reproduced.

With a two color cover, such as those we've been using this year, two drawings are required . . . one for each color. The way the two drawings are matched up is very simple. I take a heavy sheet of tracing paper and put it on top of the drawing which has been entirely drawn in blue pencil and then trace off what I want in the other color and then ink that in. The first drawing has only that part inked in which I want for it's own particular color. The very last thing is putting cue marks on, which are nothing more than little circles with crosses inside these are put outside of the illustration at each corner of the original drawing and then traced off on the second one. This is so that the final metal plates can be matched up and you won't have one color over-lapping another like you find in the comic section of your Sunday paper every once in a while. Then I write on each plate the color I want them to be printed in.

The engraver takes over now. He takes a reduced photo of the drawing on metal. He spread an emulsion on, which sticks to only the part that is the photograph. He dips it in an acid which eats away the exposed metal, doing this for a short interval several times or the acid would start eating away under the emulsion.

That's about all there is to it. The printer runs each plate through the ink I asked for and you have your cover. The next step is yours. You buy it, look at it . . . and I hope notice the cover (with a favorable impression). When the drawings leave my hands my fingers are constantly crossed. I know pretty well what it's going to look like, but there is nothing like the finished, printed thing.

So, I sit back, relax and sigh, "Another one finished." Then the phone rings. I pick it up and the voice at the other end says, "Hello, Dave. This is Howie Hadler. I've got the assignments and articles for next month's issue." And I start again.

● Robert (Bob) McNew was graduated from Purdue University in 1950 with a B.S. in "double E."

He came to Allison the next year and currently is in the Instrumentation group, Electronics and Parts Test Department.

It's partly through his efforts that Allison has enjoyed considerable success in reducing noise conditions affecting both in-plant employes, as well as residents living in the vicinity of the Allison plants in Indianapolis. For example, noise coming from turbo-jet engines while on test stands now is being reduced in intensity by a ratio of 100,000 to 1 before it reaches the outside of the test cells.

In the photo above, Bob is adjusting the sound level indicating and recording instruments in preparation for measuring the silencer attenuation of a turbo-prop engine test cell. Equipment includes the latest type of general radio sound-level meter and octave-band noise analyzer, and the magnecord tape recorder.

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Cable specifications an

THE POSSIBILITY of fires and personal injury connected with distribution of electricity by means of wires and cables, means that such wires must conform to certain minimum requirements. This was recognized in 1881 by New York's Board of Fire Underwriters, when it outlawed the use of bare or uncovered wires for the distribution of electricity in buildings and adopted "A standard for Electric Light Wires, Lamps, etc." This standard contained five rules, one for the conductivity of the conductor, one describing the insulation and the other three dealing with installation of electrical equipment. The rules for the conductor and insulation read as follows:

"1. Wires to have 50 percent excess conductivity above the amount calculated as necessary for the number of lights to be supplied by the wire.

"2. Wires to be thoroughly insulated and doubly coated with some insulating material." These two rules constitute the first effort to set up limits or to be specific with regard to insulated wire for power distribution. In other words, they constitute the first specification for insulated wires and cables for the distribution of electricity.

Historically, the next important concept concerning the covering was that of its insulating properties or its ability to confine the potential to the conductor. This was established by setting up minimum thickness of the insulation for the various conductor sizes and providing requirements for test voltages and insulation resistances for these thicknesses. Such requirements were included for the first time in the National Electrical Code for 1899. The insulation thickness for rubber insulation for a given voltage service and conductor size was essentially the same as that used today, namely, 3/64" on size 14 Awg. for 600 volt cable. The test voltage requirement was 3000 volts per 1/64" of insulation thickness, after immersion in water, distinctly more severe than present requirements. The insulation resistance requirement for 600 volt wire was 100 megohms per mile. The 1899 code also contained requirements for the dimensions of copper conductors and for tinning of conductors for rubber insulated cables. There appeared here, for the first time, a requirement for braids.

This was followed by the establishment of minimum requirements for tensile strength and elongation of rubber insulations in the original specification of the Association of American Railroads in 1905 and Underwriters' Laboratories, Inc. Standard about 1911. The 1905 specification of A.A.R. also included requirements for the chemical composition of thirty percent rubber insulation. These requirements were later adopted by Underwriters' Laboratories, Inc. and the American Society for Testing Materials.

Although aging requirements for rubber insulation were proposed in connection with the first specification of the Assoc ation of American Railroads, it was no until 1933 issue of Specification D 27 c the American Society of Testing Materia that aging became an industry specifica tion requirement for rubber insulation. The requirements for heat-resisting rubbe were included for the first time in A.S.T.M specifications for 1937. The requirement for moisture resisting rubber insulatio were established about this time. The re quirements for Polyvinyl Chloride an Laytex insulations were established in th National Electrical Code of 1940. Sinc then the requirements for the various syn thetic rubber insulations have been set up

During this period, other types of insu lations such as paper, varnished cambri and asbestos and many types of sheath and coverings for wires and cables wer developed. More detailed requirements fo conductors were also established. Ther are today, therefore, a wide variety o cables for use in the distribution of elec tricity for power and control purposes.

Practically every element of these wire and cables is covered by detailed specif cation requirements or standards. Ther are specifications for bare or uninsulate wires and cables, for covered wires, suc as weatherproof wire and all insulate wires and cables, regardless of the type o insulation or coverings. Such specification cover, in detail, the construction and re quirements for the conductor, the thick ness, physical, aging, electrical, moistur

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standards

and ozone resisting properties of the insulation, the construction details of the cables and the thickness and other properties of the covering or sheath. These specifications are issued by literally hundreds of manufacturing organizations, municipalities, railroads, utilities, government agencies, etc. They may differ only slightly but significantly, in certain details, thus making it necessary to run many wires on special orders. The wire and cable industry is thus obviously specification conscious. In fact, it is probably true that all types of wires and cables used today are more completely covered by specifications than any other class of commercial products of equal complexity.

Specifications have thus become a necessary and important part of the wire and cable industry. When properly prepared on the basis of sound engineering, information and manufacturing practices, they provide for durable, economical and safe cables for any particular application. They describe the item in a clear and concise manner that can be readily understood by any one familiar with the industry. They form the basis for contracts between cable users and cable manufacturers, and eliminate or minimize any questions that might arise concerning the construction or quality of the cable under consideration. A working knowledge of wire and cable specifications is essential for those interested in the development, manufacture and use of wires and cables.

US RUBBER

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The Machine with a Memory

(From National Bureau of Standards)

Recent Developments and Operating Experience

SWAC—the National Bureau of Standards Western Automatic Computer—is now being operated 24 hours a day, five days a week to solve a wide range of complex problems in physics, engineering, mathematics, statistics, and meteorology. At present over 70 per cent of this time is devoted to problem solution, the remainder being reserved for maintenance, engineering development, and testing of new equipment.

SWAC is a general-purpose digital computer constructed by NBS in 1950 under the sponsorship of the Wright Air Development Center. The first of the high-speed electronic computers to be completed with the very fast Williams tube (cathode - ray tube) memory, SWAC operates at a rate of 16,000 addition or 2600 multiplications per second.

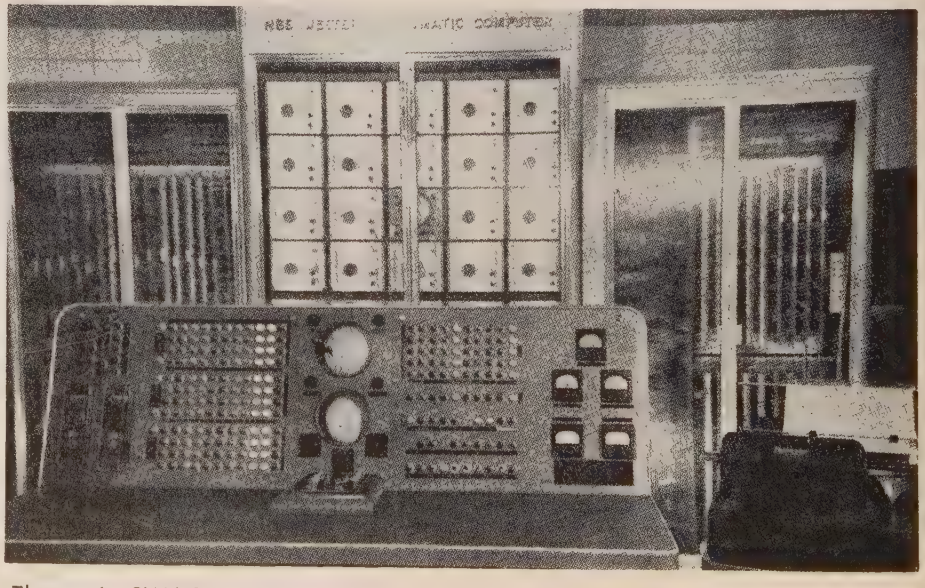
Recently the scope and complexity of the problems which the machine can handle have been greatly extended through the installation and successful operation of a magnetic drum auxiliary memory. Based on the principle of the magnetic-tape recorder, the new memory holds 16 times as much mathematical information as the cathode-ray tube memory, with which it will be used to increase the over-all memory capacity of the machine. The magnetic drum will also act as a storehouse for a library of numerical methods or routines of instructions which, when obeyed by the machine, can facilitate the solution of a large class of problems.

SWAC was designed and built at the NBS Institute for Numerical Analysis in Los Angeles to provide a rapid, powerful computational tool on the West Coast and to aid in the Institute's program for the further development and increased utilization of the art of machine computation. The ultra high-speed machine has been used by NBS principally to solve aircraft problems originating with the Air Force and its contractors, other problems in science and engineering submitted by Government agencies, and mathematical problems arising in connection with the Bureau's work on computation methods and computing machine development.

SWAC's high speed results from its special Williams tube memory and its parallel mode of operation. The memory unit consists of a bank of cathode-ray tubes which store information as bright spots of charge. The unit is operated in parallel, that is, all the digits of a number are transferred in or out of the memory simultaneously, thus greatly reducing the time required for transfer of information. In serial machines, such as those using acoustic-delay-line memories, numbers and instructions are represented by trains of electrical pulses. But in SWAC parallel circuits transfer numbers and instructions almost instantly, within the time of a single pulse (about one tenth of a microsecond). Arithmetic operations are also carried out in parallel, with a consequent increase in speed of computation. In its parallel method of operation SWAC differs from SEAC (National Bureau of Standards Eastern Automatic Computer), a serial machine constructed by NBS at its Washington (D. C.) laboratories.

Magnetic Drum Memory

While the cathode-ray tube type of memory delivers information at a very rapid rate, its capacity is limited by the number of digits that can be stored on the face of a single cathode-ray tube. To provide greater flexibility and computing power, a magnetic drum external memory was developed by Thorensen and associates of the NBS staff. With the drum memory, many complicated types of problems can be handled by transmitting information out of the computer for storage and then feeding the



The main SWAC computer, control console, and input typewriter. (This computer is very similar to the one at the University of Illinois, The Illiac.)

information back into the computer at a later stage of the problem.

SWAC's drum memory, like those developed elsewhere, is a revolving metal drum which retains numbers and instructions on its surface in the form of magnetic pulses like those used in tape recording. At intervals, blocks of magnetic pulses are removed from the drum by a magnetic head and are taken into the computer to be transformed electronically into spots of charge in the Williams tube memory, where they remain until called for by the control unit.

SWAC stores and processes information in units called words, each word consisting of 37 binary digits, the equivalent of 11 decimal digits. The magnetic drum has a capacity of 4096 words of 37 binary digits each, in contrast with the 256-word capacity of the cathode-ray tube memory. This high-capacity memory makes possible the solution of very large sets of simultaneous equations, such as arise in logistics; certain types of partial differential equations which occur frequently in aeronautical research, in heat-transfer problems, in electro-magnetic theory, and in other fields; and combinatorial problems, applications of which have recently engaged the attention of scientists. Instruction routines stored on the drum will handle, among other things, the conversion of information from a decimal representation into the binary representation used by the machine, as well as the final conversion back to decimal form when it is required to print out results.

In the construction of the magnetic drum, primary consideration was given to simplicity of design and maximal efficiency in the transfer of information between it and the cathode-ray tube memory. A drum memory ordinarily has a much larger capacity than a Williams tube memory, but access to a drum memory is generally slow. In particular, if information is required from some specific location on the drum, the computer may have to wait up to a maximum of one drum revolution before receiving any information. However, in the magnetic drum memory developed for SWAC, access time is shortened in two ways: (1) Numbers are transferred in sizable blocks from the magnetic drum memory to the cathode-ray tube memory, thus minimizing the total number of times the drum memory must be consulted. (2) The numbers in each of these blocks are stored sequentially around the circumference of the drum so that one block forms a band or channel completely encircling the drum. When a transfer to or from the drum memory is made, the whole channel is handled at one time. Transfer of information starts immediately after the proper channel has been selected and continues for exactly one drum revolution thus elimination all waiting time. In this way the access time per word is reduced to 500 microseconds—about 1/30 of the normal access time of a magnetic drum memory.

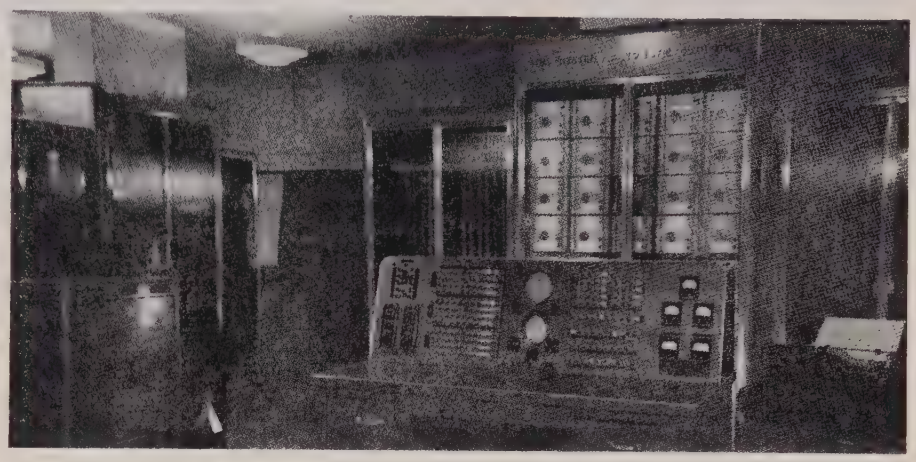
Information is stored serially on the drum in 40-binary digit words. The first 36 digits represent numerical information, the 37th digit gives the algebraic sign, while the remaining three digit positions are empty. Thirty-two words are stored in each channel and constitute a basic transfer block. As the drum rotates at 300 revolutions per minute, 32 words are transferred in approximately 17 thousandths of a second.

The drum contains 128 information channels plus four timing channels. The timing channels feed a timing generator, which generates a pulse for each digit space, a pulse for each word space, and a reference pulse for each revolution of the drum. The pulses marking each word space go to an *address counter*, which counts from 0 through 31. This counter continuously keeps track of the word space as they pass under the magnetic read-write heads. The reference pulse is used to initially synchronize this counter with the drum.

The cathode-ray tube memory operates in parallel with the serial magnetic drum memory, and the two are not in synchronism. Direct communication between the memories is therefore not possible. Information from the drum must first be played back into a vacuum-tube shifting register and then transferred in parallel to the cathode-ray tube memory. Each digit takes 13 microseconds to play back, so the three empty digit spaces in each word give total delay of 39 microseconds between words. This delay is more than adequate for transferring a number from the register to the cathode-ray tube memory and for clearing the register to receive new information

The entire drum memory system consists of less than a dozen different types of basic single-tube plug-in units that are developed to a high degree of stability under a variety of conditions of loading and aging. Only about 250 vacuum tubes are used.

In addition to the drum memory, plans call for a slow-speed auxiliary memory consisting of a magnetic-tape unit. It will have a much larger capacity than the other two memories, holding approximately 4,000,000 binary digits, but its average access time will be quite long—about 3½ minutes.



The SWAC system. IBM input equipment and magnetic drum memory unit, at the extreme left. The computer and console are at the extreme right.

Description of SWAC

SWAC is automatically sequenced, that is, it automatically performs all of the logical and arithimetical operations required to solve a particular problem once it is supplied with coded instructions and numerical data. The computer stores in its high-speed memory not only the numbers involved in the computation but also the instructions necessary to perform the computation. This makes it possible for the calculator to use fully the speed of the Williams tube memory, doing complete arithmetic operations in a few microseconds.

The computer proper is housed in a single console approximately 12 feet wide, 5 feet deep, and 8 feet high. It consists of three major parts: an arithmetic unit, a memory unit, and a control unit. Four other parts complete the computer system; they are the magnetic drum memory, the input- output units, the operating console, and the power supply.

The arithmetic unit performs the arithmetic operations of addition, subtraction, and both rounded-off and exact multiplication. It also performs the logical operations of *comparison* and *extract*. Comparison involves changing the course of the computation depending on the relative sizes of two numbers. Extract divides numbers up into parts which the computer can handle in different ways.

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The arithmetic unit receives information from the memory in the form of numbers to be operated upon and instructions as to the nature of the operation. Having acted upon such instructions and completed the operation, the arithmetic unit returns the answer to the memory.

The memory feeds its information to the arithmetic unit in accordance with instructions it receives from the control unit. The control unit consists of electronic circuits which control the operations of the computer proper. This unit takes information from the input unit, directs it to the memory, tells the memory when to send information to the arithmetic unit, tells the arithmetic unit when and where to return answers to the memory, and controls the feeding out of completed solutions to the output unit.

SWAC uses both a punched-card input-output system and a paper-tape system. For card input, the coded problem is punched on a standard IBM card, and the answer is received in the same way. In the paper-tape input-output system, a coded problem punched in paper tape is fed into the machine, and answers are automatically given in typed form by an electric typewriter.

The operating console, an office desk with specially built panels mounted on its top surface, permits the human operator to control the operations of the machine and to watch the machine as it operates. The console is provided with control switches and neon lights which indicate what is taking place inside the machine. Oscilloscope screens make it possible for the operator to view the memory pattern of any given unit of the Williams tube memory.

SWAC is supplied with electrical power, carefully regulated in voltage, by means of a motor-generator set and related equipment, largely electronic in nature. The computer is thus isolated from line voltage fluctuations which might affect its operation. About 30 kilowatts are consumed when the machine is operating.

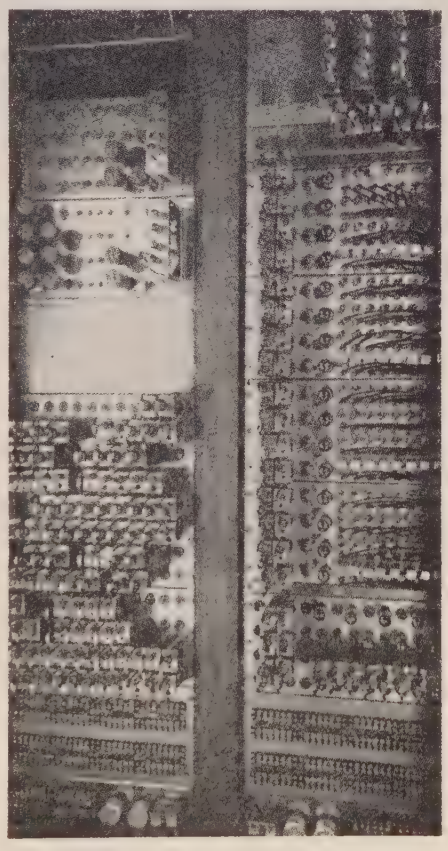
Williams Tube Memory

The Williams tube memory consists of a bank of 37 cathode-ray tubes, each of which can store 256 digits on its face in a matrix pattern of dots and dashes. The dots represent "0" while the dashes represent "1". As SWAC is a binary machine, all decimal numbers and instructions are fed into it in a code which utilizes only the digits 0 and 1.

The number of digits that can be stored on the face of one cathode-ray tube determines the number of words that can be stored in the memory. That is, the *n*th cathode-ray tube stores the *n*th digit of each word. Thus, a given word has one digit stored in the same relative position in each of the tubes. This makes it possible to position all of the electron beams at a given location, or *address,* in the memory and thus to transfer all of the digits of a word simultaneously. As a result, the time required to transfer a word to or from the memory is only 16 microseconds.

To produce either a dot or a dash at a given spot on the face of a Williams tube unit, the electron beam is turned on to produce a spot of charge on the screen. If the beam is left on only long enough to establish equilibrium and is then turned off, a dot is produced. If the beam is left on longer and is deflected from the dot position by the superposition of a small sawtooth voltage on the positioning voltages, a dash is produced. The dots and dashes are read off by an amplifier, which picks up the signal from the tube screen, amplifies and reshapes it, and causes the electron beam inside the tube to place a signal back on the face of the tube.

Unless this type of storage is continually renewed or regenerated, the original charge pattern tends to disappear over a period of time as the charged spots gradually collect stray electrons. Thus, to provide continuous storage, an electron beam is made to inspect successively each point of charge and to energize electronic circuits which, when necessary, restore the charge to its initial value. The regeneration process takes place during short intervals which alternate with the reading-in or reading-out of information in the memory. In this renewal process the machine spends only 8 microseconds on each point of charge on the face of the tube, and complete regeneration occurs 250 times a second. Such a continuous regeneration process makes it possible to store information indefinitely. A crystal-controlled oscillator regulates both the rate of regeneration of the memory and the operations of the arithmetic unit.



Magnetic drum switching matrix and control circuits.

Operating Experience

SWAC contains about 2600 tubes and 3700 crystal diodes. The average tube life is between 8,000 and 10,000 hours. To date, very few tubes have been lost on account of heater failure. The largest percentage of tube failures have resulted from low emission and intermittent shorts.

All electronic components in the computer proper are mounted on removable plug-in chassis, so that faulty operation can usually be corrected by replacing a bad chassis with a good spare. The faulty chassis can then be repaired in the laboratory without loss of computer time. The majority of the plug-in chassis contain an average of 10 tubes each; however, the magnetic drum circuits are built of much smaller units, usually consisting of a single tube.

One of the difficulties encountered with the cathode-ray tube type of memory is "spillover," or redistribution of charge, which limits the number of times the spots adjacent to a particular spot may be read before the spot in question must be regenerated. To mitigate this difficulty, circuits have been installed which eliminate most of the drift in the patterns on the face of the tubes. A substantial improvement in operating time has resulted.

Other improvements have been achieved by rebuilding certain parts of the circuitry which have shown a high out-of-order maintenance time. A substantial improvement in operating time occurred when an air-conditioning unit was installed to maintain the incoming air in the ventilation system at a constant temperature. This minimized the temperature cycling of crystal diodes and substantially decreased their failure.

General operating efficiency has also increased by the addition of a loudspeaker and buffer tube with a plug-in arrangement allowing the operator to "listen" to any of the commands in a problem. For example, an alternate succession of add and subtract commands produces an eight-kilocycle note.

Recently, by addition of one tube and a few crystals, a converting output command was obtained. This command, effective only with the output typewriter and tape punch, converts fractional

binary numbers to octal, decimal, or any other base up to 16.

Problems Solved

During the eight month period ending June 1, 1953, SWAC spent an average of 53.2 hours a week in actual computing. The remainder of the operating time was spent in code checking, memory adjustment, maintenance, testing of components, and development of improved facilities. More than 50 problems were handled in the past year, ranging from minutes to hundreds of hours in running time. During this period the punched-card input-output system was operative, but the magnetic drum had not yet been installed.

Problems in least squares, reduction of data, heat transfer, stress analysis, and a tremendous variety of other physical phenomena can be described by systems of linear equations. However, most of the methods now in common use for solving such equations are variations of the elimination method developed by Gauss. These methods all tend to yield answers of low significance when the matrix of the coefficients is almost unity. Using SWAC for extensive numerical trials, M. R. Hestenes and E. Stiefel of the NBS staff recently developed a new approach, known as the conjugate gradient method, which appears to have broad utility for the solutions of problems arising in applied physics and engineering. SWAC has now solved many systems of equations of order 10 to 15. Codes have been prepared for the solution of systems of any order up to 45, but no system of that high order has as yet been solved. However, the characteristic values and their associated vectors have been found to nine significant decimal digits for a 45th order system, as well as for systems of order 10 to 20.

In the field of differential equations, a large amount of computing time has been devoted to the study of associated Legendre functions, $p_{m/n}(x)$, which are important in mathematical analysis of radiation fields from antennae. The specific problem was the determination of the nonintegral values of the order (n) which, for fixed values of degree (m) and argument (x), would make the value of the function zero. For each combination of m and x, an infinite set of discrete values of n will satisfy the requirements. SWAC found the first 30 values of n corresponding to one value of x and three values of m.

With the aid of SWAC, NBS has carried on research in the application of the so-called "Monte Carlo" method to the solution of complicated differential equation and of previously unsolved statistical problems in nuclear physics. The Monte Carlo method, developed by J. von Neumann of the Institute for Advanced Study at Prinecton and S. Ulam of Los Alamos Scientific Laboratory, is a new mathematical technique which solves a physical or mathematical problem by creating an artificial statistical model of the physical or mathematical process involved. It applies the same techniques that are used in analyzing games of chance to the analysis of physical problems where the events are random and are governed by the laws of probability. Large-scale computers such as SWAC provide an excellent means for the solution of problems of this kind because they are able to create conditions which imitate the statistical behavior of the given problem. Thus, the randomness of the event can be taken care of by putting into the extended memory of the machine a set of random numbers which are first tested for their random quality. SWAC has been used to compile large groups of random digits, to explore their statistical behavior, and to investigate their utility for solving partial differential equations by random walk processes. Recently problems concerning nuclear forces have been attacked by means of the Monte Carlo method.

Problems in the evaluation of definite integrals have arisen from studies in probability and statistics. One such problem, the computation of a table of survival probabilities for biological experiments, required the evaluation of 21,500 double integrals with each variable ranging from plus to minus infinity. This table was computed in 177 hours. A second table, for biological experiments in which the exact level of a radiation dose is unknown, required the evaluation of 7500 single integrals, this time with an infinite lower limit and a finite upper limit.

Many applied problems have dealt with the reduction of large blocks of data. A study of the large-scale circulation patterns in the earth's atmosphere was typical. Some 750,000 pieces of data, each five decimal digits in length, were processed to yield about the same number of answers. SWAC spent 325 hours on this problem.

SWAC has also been applied to several combinatorial problems. In some it has exhaustively searched through all possible combinations of the variables. One such problem was that of finding *difference* sets, that is, a set of n numbers such that all n(n-1) nonzero differences give distinct remainders when divided by n^2-n-1. Another problem, involving permutations, dealt with the optimal assignment of duties in an organization.

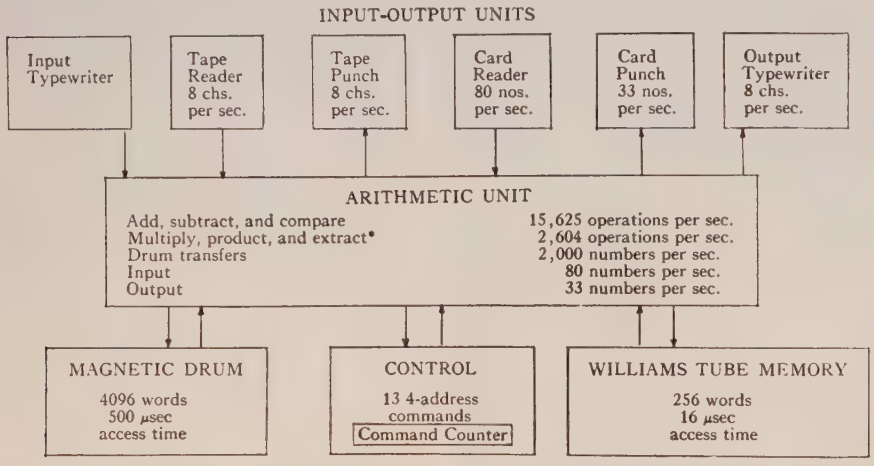
SWAC has proved an effective tool for the analysis of Fourier synthesis of X-ray diffraction patterns of crystals. Such analyses, at present being carried on by members of the Chemistry Department of the University of California at Los Angeles, lead to the determination of the arrangement of molecules inside the crystals.

In the field of pure mathematics, SWAC has been used to study the primality of Mersenne numbers, that is, numbers of the form 2^p-1, where p is a prime. These numbers, when prime, are related to the "perfect numbers" of the Greeks, which are the sum of all their integral divisors excluding themselves. The present list of values of p which yield prime numbers is as follows:

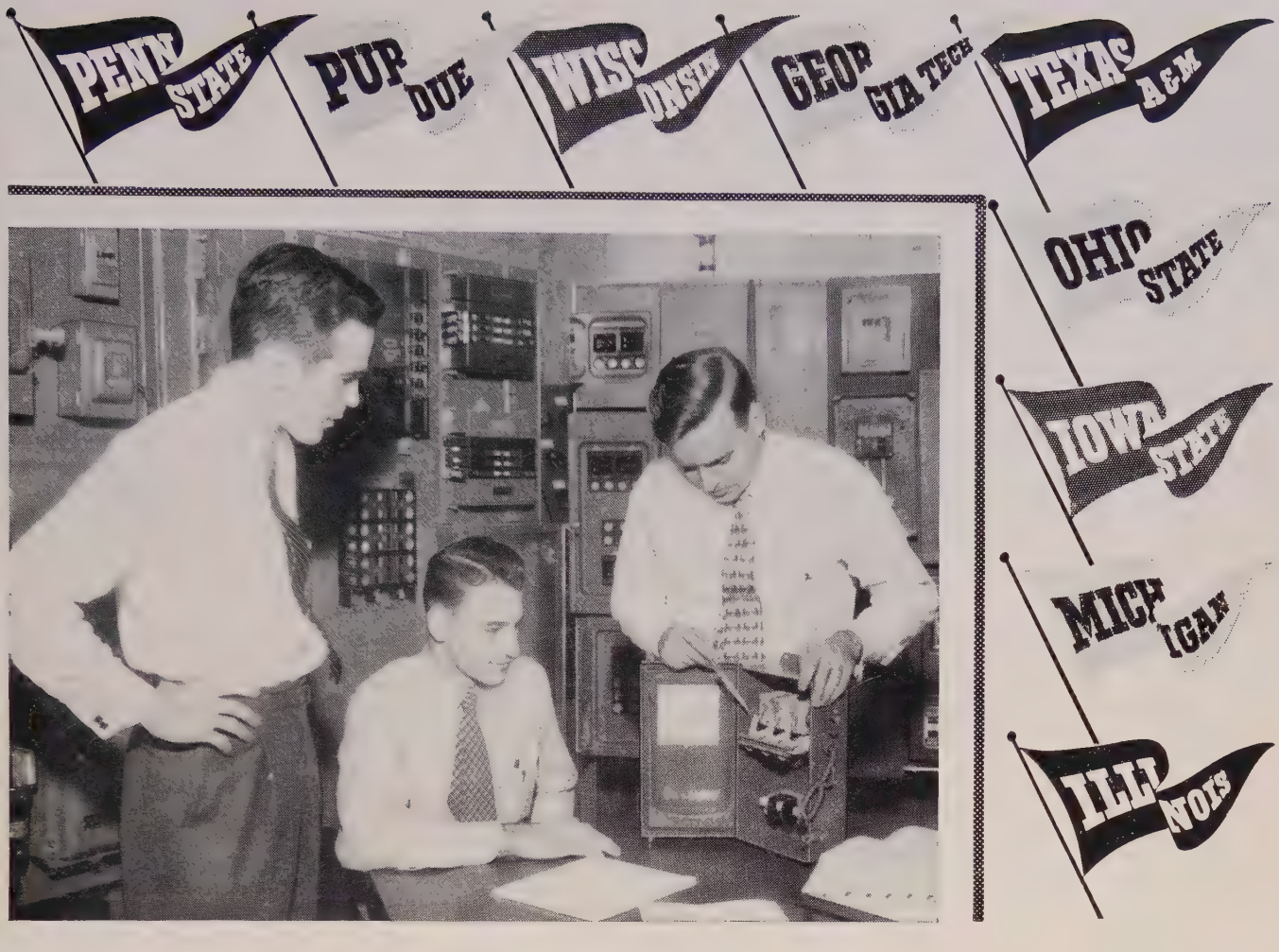
2, 3, 5, 7, 13, 17, 19, 31, 61, 89, 107, 521, 607, 1279, 2203, and 2281.

The last five values were added to the list by SWAC as a result of the systematic testing of all prime numbers up to 2297.

Mathematical research directed toward more effective utilization of electronic digital computers is continuing at the NBS Institute for Numerical Analysis. Further progress in this program should materially increase the scope of the problems which SWAC and other high-speed computers can handle and should also make possible additional savings in actual computing time.



Schematic drawing of the process of the SWAC computer



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by Don Culley, E. Phy. '57, Davida Bobrow, English, Mel Green, M.E. '55

ROBERT TRAPP

Most engineering physicists on campus, in fact most engineers, should have heard of Bob Trapp. He is very well known around the Physics Lab, and can be found there whenever the campus Physics Society is in session. This group, of which Bob is one of the original founders, is probably the most important activity in his busy campus life. He has been doing a very able job as president of this organization for the last two years. A senior in Engineering Physics, Bob is in many other campus activities. He has spent two years on the Engineering Council, and also serves as prexy of this group. He is a member of two scholastic honorary societies: ΣT, junior engineering honorary and ΠME, junior mathematics honorary requiring a 4.75 overall average in mathematics for membership. In addition, he serves as a member of the Executive Committee of the student ASEE (American Society for Engineering Education), and has recently become a member of IRE (Institute of Radio Engineering). In addition to his many activities, Bob has managed to maintain a 3.91 average for a total of one hundred and forty hours.

Bob hails from Taylorville, where he graduated in 1950. He is active there in scouting, in which he holds the rank of Eagle with Bronze Palm, and is assistant scoutmaster of Troop 67, Taylorville.

His usual summertime occupation is either that of lifeguard or instructor in Red Cross water safety, for which he holds a certificate.

In his four years here at school, Bob has lived as an independent. His place of residence has changed recently, however, as he became married to Nancy Holt on December 30 of last year.

At the present, Bob finds himself quite busy filling out job application blanks. If the Air Force does not take him, he hopes to land a job in physics or electronics. Best of luck, Bob. If you keep up the good work you have done here at the University, your future should be very successful.

ROBERT TRAPP

MEL GREEN

"What can you say about me, Dav? I'm just an ordinary guy." This statement is typical. Mel Green, new Navy Pier *Technograph* editor, is one of the most modest people you could meet.

Although having no previous experience in journalism, Mel joined the *Tech* staff last semester and rose rapidly to his present position. Now in his last semester at the Pier this "ordinary guy" is also publicity director of the Engineering Council, and a member of the ASME and Quad Council. He does all this while maintaining a 4.0 average!

Mel, a M.E. with a production option, plans on coming to Urbana, in September to finish his last two years. If khaki calls, however, Mel will answer. Upon ending his army stint, he hopes to go back to school and obtain a master's degree in Engineering administration.

Summer jobs have given Mel a great deal of practical experience as a draftsman, but his interest lies in the field of engineering sales.

Does he have time for hobbies? Mel admits his greatest hobby, and the one which consumes most of his spare time, is traveling. Five days a week he travels back and forth between and Navy Pier. That doesn't leave too much time for his other past-times which include reading "Mad" comics, science fiction, and photography.

One of the most conspicuous things about Mel is his belt. There is no slide rule dangling from it. Perhaps it's just the non-conformist in him asserting itself.

After knowing Mel for any length of time, you learn his favorite word—Animal. This he uses in the neuter gender, applying the epitaph to male and female alike. The shouted phrase, "Lord, what an animal!" is almost a sure way of singling Mel out in a crowd. To this day, we don't know exactly what "animal" means, but we feel certain it is something complimentary.

The Pier staff will be sorry to see Mel leave, but we know that wherever he goes, and whatever he does, Mel will be successful.

DAVIDA BOBROW

Although her name may tend to be a little confusing, Davida, the Technograph's Business Manager at the Pier, is not to be confused with any male answering to the name Dave. Dav attended Sullivan High School in Chicago where she was Editor of their newspaper, the *Sentinel,* and wrote for their yearbook, the *Navillus.* However, this alone couldn't keep Dav busy. So, she wrote a column for *Meyer's Syndicated Papers,* who are the publishers of many of Chicago's neighborhood newspapers. Dav did a lot of writing both in and out of school. She once won an essay contest by writing about the Illinois State Constitution. She also wrote a few skits and a rhymed narration for a swim show.

It is hard to imagine a person with so much to do looking for something else to do in her spare time, but Dav did just that. Due to the fact that she has always liked water, I suppose it was only

natural that she looked to swimming for fun and relaxation. Fortunately, Sullivan had a Synchronized Swim Club of which Dav became an active member.

In her last year of high school, Dav was in the Senior Play and was appointed to the Senior Prom Committee. With all of these extra curricular activities, one stops to wonder when she studied. Evidently, she must have found the time for she was a member of the National Honor Society, which recognizes

MEL GREEN

DAVIDA BOBROW

student for superior scholastic ability, and upon graduating, she was named one of the outstanding graduates by a Chicago newspaper.

Although now an English major, it is no surprise that Dav was attracted to the Technograph as soon as she came to the Pier, for she has newsprint in her blood. She soon took over the position of Business Manager and all of its many responsibilities with the greatest of ease. Dav is also on the news staff of the *Pier-Illini* for which she writes regularly.

For the few months that Dav has been in college, she has proven herself to be a hard worker, and I know she will excel in everything that she will do here just as she has done in the past.

The two stones most commonly associated with marriage are the diamond and the grindstone.

* * *

An old man marrying a young girl is like buying a new car when you can't drive.

* * *

An experienced stenographer is one who knows how to keep her boss from ending a sentence with a proposition!

* * *

Golf is a game in which a ball 1½ inches in diameter is placed on another ball 8,000 miles in diameter. The object is to hit the small ball but not hit the large one.

* * *

The professor has been lecturing to a very inattentive group: "Class dismissed, and don't flap your ears or bray on the way out."

* * *

Many girls leave nothing to a man's imagination and everything to his self control.

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Graduate
with experience in
Radar
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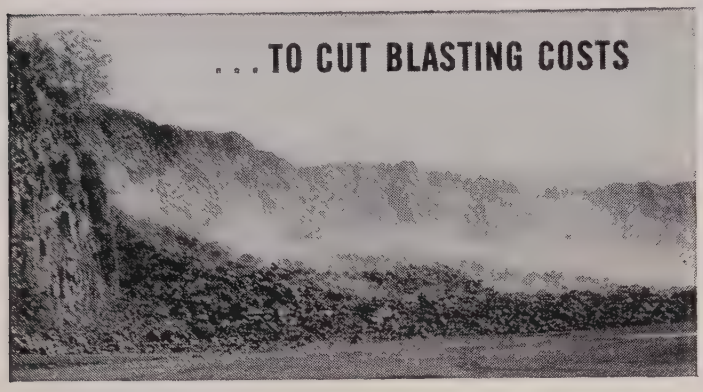
In quarrying, as in metal mining, coal mining, and construction, proper blasting with the proper explosives promotes higher production . . . easier work for men and machines. Hercules' 40 years of experience in the development, manufacture, and use of explosives mean top efficiency and economy.



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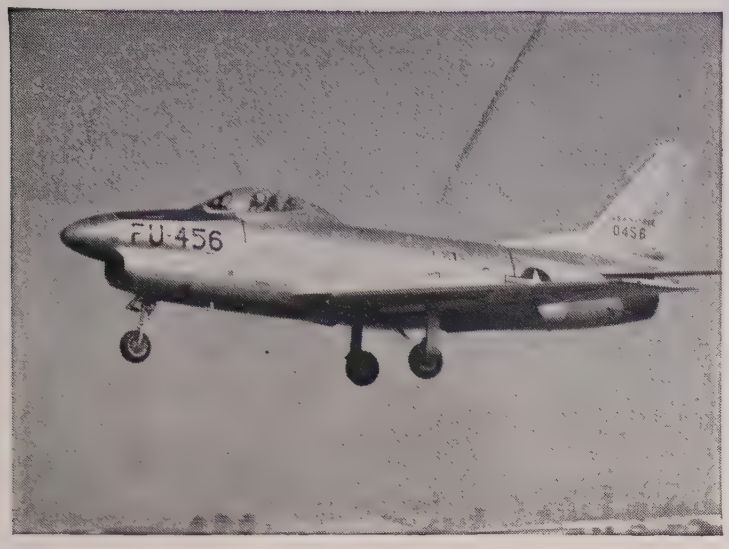
HERCULES

Another page for **YOUR BEARING NOTEBOOK**

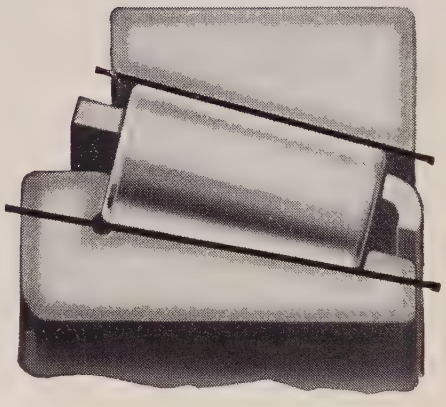


Jet's wheel bearings have to take three kinds of forces

When the F86-D Sabre Jet lands—the wheel bearings take a triple beating. There's the initial landing shock, an almost instantaneous acceleration; and, if there's a crosswind, heavy thrust loads. Bendix and North American solved this triple punch problem by using Timken® tapered roller bearings for all three landing wheels. Their tapered design enables them to take radial and thrust loads in any combination. And Timken bearings' true rolling motion and incredibly smooth surface finish practically eliminate friction permitting rapid acceleration.

Line contact helps TIMKEN® bearings take jet landing load

This cross-section drawing shows one reason Timken bearings are ideal for taking the heavy landing load of the plane itself. Note the full line of contact between rollers and races. This gives Timken bearings high load capacity. It's a basic advantage of roller bearings.



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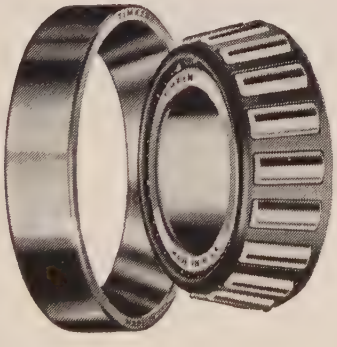
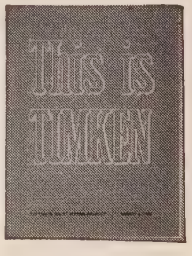


Want to learn more about bearings or job opportunities?

Some of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◎ AND THRUST ⊣◎⊢ LOADS OR ANY COMBINATION ✳

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Architecture

by Dave Webster
Arch. '58

Architecture is a science-art, with twin roots in asthetics and engineering. Unlike painting and sculpture, the architectural work of art (home, school, city hall, bank, church, factory) cannot be brought into existence in the isolation of a studio. True, the building is first conceived and planned in the mind of the architect and then is blueprinted on the drafting board. But it is built in life, in the world of brick and stones, of mortgages and taxes, of rentals and vacancies.

Architecture is a practicing art, and a practical art. Its plans are carried to material completion in a hurly-burly of donkey engines and steam shovels, electric riveting machines, acetylene torches, plus a medley of sidewalk superintendents. Even in traditional American wooden frame houses, the ring of the handcraft carpenter's hammer sings of actiity, as does the wet swish of the handcraft house painter's brush.

Architecture is the most basic of the arts. Today, as at the dawn of history, it satisfies the need for physical protection and for psychological security. It feeds, also, the individual's hunger to be one of the human community. These aspirations, rooted in primitive man's early experience, express themselves differently today; nonetheless they root architecture in human feeling.

Contemporary architects call their vocation by new names. Present-day mass production industrial civilization has created a new art, they say. Some suggest shelter instead of the rhetorical greed work derived from "master-builder." Others prefer design correlation, design co-ordination or design synthesis to suggest the fact that the architect is a designer who integrates a variety of skills, techniques, bodies of knowledge, and methods of procedure.

Two great wars have accelerated, by scientific discoveries, the production of new materials. The automobile and airplane have altered our concepts of space and time. Aesthetic embellishment in the sense of applied ornament does not seem to fit the period in which we live. Mounting costs of materials and labor have limited the ability to build and increased the need for initiative and imagination in achieving economy. The practicing architect has had to re-evaluate his approach to design.

Architectural design was formerly based on an understanding and adaption of historic styles. Traditional materials used in uniform ways developed established procedures which helped to standardize building costs. Public buildings were often palatial, and a $25,000 house was a mansion. A five room house of today costing about $10,000 could have been built in the 1930s for $3,000 or less.

Architecture and engineering, like medicine and the law, tend to close their gates to women. One well-known university will not allow women to attend its day classes, only its evening classes! In 1940 only 2.3 per cent of 21,976 architects were women.

Architects were formerly trained in ateliers or studios. The formal curriculum for the architectural student is of recent origin. A half century ago architects were still taught in a master-apprentice relationship. If the master was a good architect, the system was well enough. In general, however, it fastened a Beaux-Arts tyranny on the American scene, as may be seen in the pseudo-classical structures that dot the native landscape.

Illinois has a license law for architects. To obtain this license you should have a degree of bachelor of architecture, or its equivalent, you must have served at least one year in the employment of a registered architect, and you must pass a written examination. As the present laws stand it is not necessary to have a degree in architecture, but one must spend at least ten years in apprenticeship to a master architect.

Specialization ultimately evolves out of mature experience, and successful practicing architects acknowledge this by their insistence on well rounded college training for the architectural student.

An ex-GI studying industrial engineering in 1949 was discovered by his wife one night standing over his baby's crib. Silently she watched him. As he stood looking down at the sleeping infant, she saw in his face a mixture of emotions that she had never seen before—rapture, admiration, doubt, despair, ecstasy, incredulity. Touched and wondering alike at his unusual parental attitude and the conflicting emotions, his wife, with eyes glistening, arose and slipped her arms around him. "A penny for your thoughts," she said in a tremulous voice.

He blurted them out: "For the life of me, I can't see how anybody can make a crib like that for three forty-nine."

Engineering Opportunities

by Fred L. Maytag II

Fred L. MAYTAG, II, president of The Maytag Company, Newton, Iowa, is the third generation head of the washing machine manufacturing company which bears his name. One of the country's leading manufacturers, Mr. Maytag is active in a wide range of business, industrial and public affairs. He is a member of the board of directors and chairman of the taxation committee of the National Association of Manufacturers, trustee of Grinnell College, Grinnell, Iowa, and a member of the board of governors of the Midwest Research Institute. A former Iowa State Senator, he has received numerous special recognitions for his accomplishments, including a ten-page picture layout in Life Magazine featuring his community activities. Mr. Maytag is an enthusiastic flyer and pilots his own plane on business and pleasure trips.

A casual glance at the classified advertisements in any of our metropolitan newspapers, today, makes it apparent immediately that there is a tremenodus demand in industry for graduate engineers of all types.

This demand has grown to its present proportions because of two basic conditions: An insufficient supply of graduate engineers, and a tremendous increase in the number and types of industrial jobs requiring engineering graduates.

As industry, generally, has advanced, the complexities of its operation have increased markedly. As mass production techniques have been developed, the need for technical know-how has grown correspondingly. In the development of new products, and the improvement of existing products and processes, industry has found it necessary to depend more and more upon the engineer.

There was a time, not so long ago, when the engineer was required in industry primarily to direct the maintenance and research activities required by the employer. Long since, however, employers have been looking to engineers to fill an increasingly large percentage of positions concerned with the production function. Gradually, employers have begun to fill the vacancies in top management positions with engineers who, because of their technical training and experience, are able to comprehend the problems of production management, as well as those of the specialized staff functions.

For these reasons, there is almost no limit to the opportunities available to competent graduate engineers. I would add one word of caution, however, and that is this: Industry is more and more concerned in finding in its engineers, something more than mere technical competence, or even technical brilliance. Industry wants engineers who, in addition to their technical competence, have an adequate concept of historical and sociological aspects of the industrial function. Furthermore, industry wants in its engineers, a facility for maintaining satisfactory personnel relationships. Industry is concerned in employing engineers who are, first of all, good citizens in the broadest sense of the term; and who are, secondarily, good engineers.

The present employment opportunities for engineering graduates are undoubtedly the best in the history of our economy. Even the man who has narrowly specialized, at the expense of developing "the whole man," can almost write his own ticket—initially. Furthermore, he can feel reasonably assured that industry's need for his specialized skill will not diminish.

But the opportunity to rise higher in the ranks of management, to positions of broader responsibility, will increasingly be reserved to those engineers who combine a high degree of technical competence with a truly liberal education, superior ability to establish and maintain good interpersonal relationships, and marked capacity for continued personal growth.

Little Willie, He's a brat,
Broke an egg in Daddy's hat.
Then he laughed in fiendish glee,
When Poppa said, "The yolk's on me."

* * *

You haven't really proved
If you are a man or a mouse
Until you've spent a winter
With plumbing outside the house.

* * *

"Tell me, Duke," asked the solicitous American host as his French guest landed in New York, "what is the first thing you would like to see in the United States?"

"Zat ees easy," said the visitor. "First I weesh to meet ze amazing Madame Beech who had zo many sons fighting weeth ze Americain Army to save France in ze last war."

Mass production is the key to America's industrial development and every manufactured need can trace its beginning back to machine tools and precision measuring tools.

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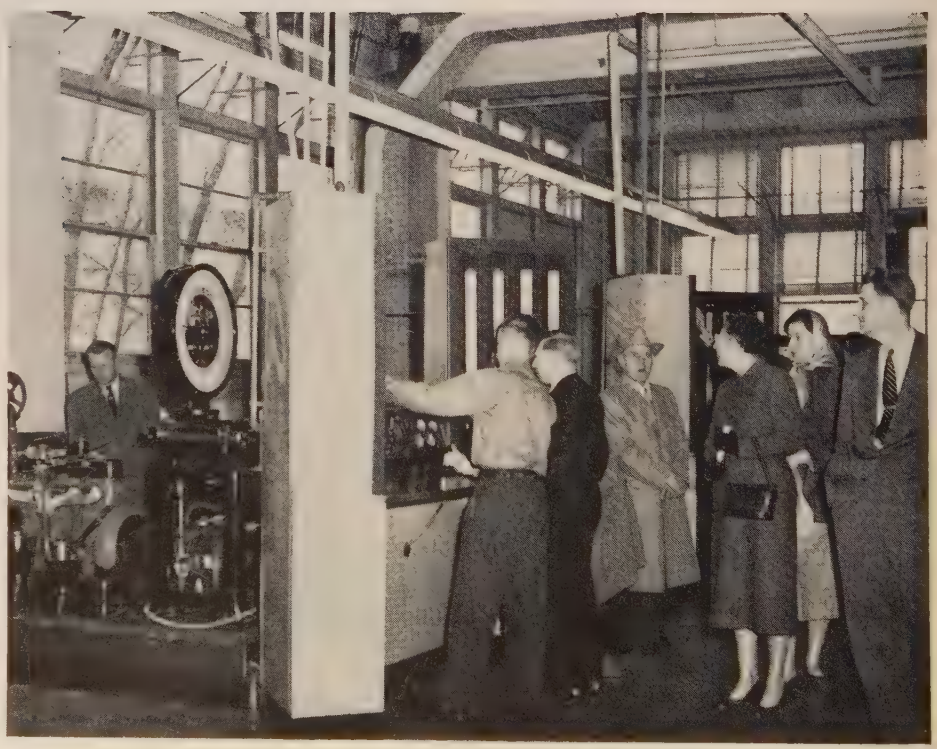
1954 ENGINEERING

The Physics Department's demonstration of static electricity. The physics students are shown giving a demonstration to an Open House audience. These exhibits won the first place for the best displays as judged by the high school students. Other physics displays were gyroscope, and inertia experiments, liquid nitrogen and air, Van de Graff generator, and cosmic ray telescope.

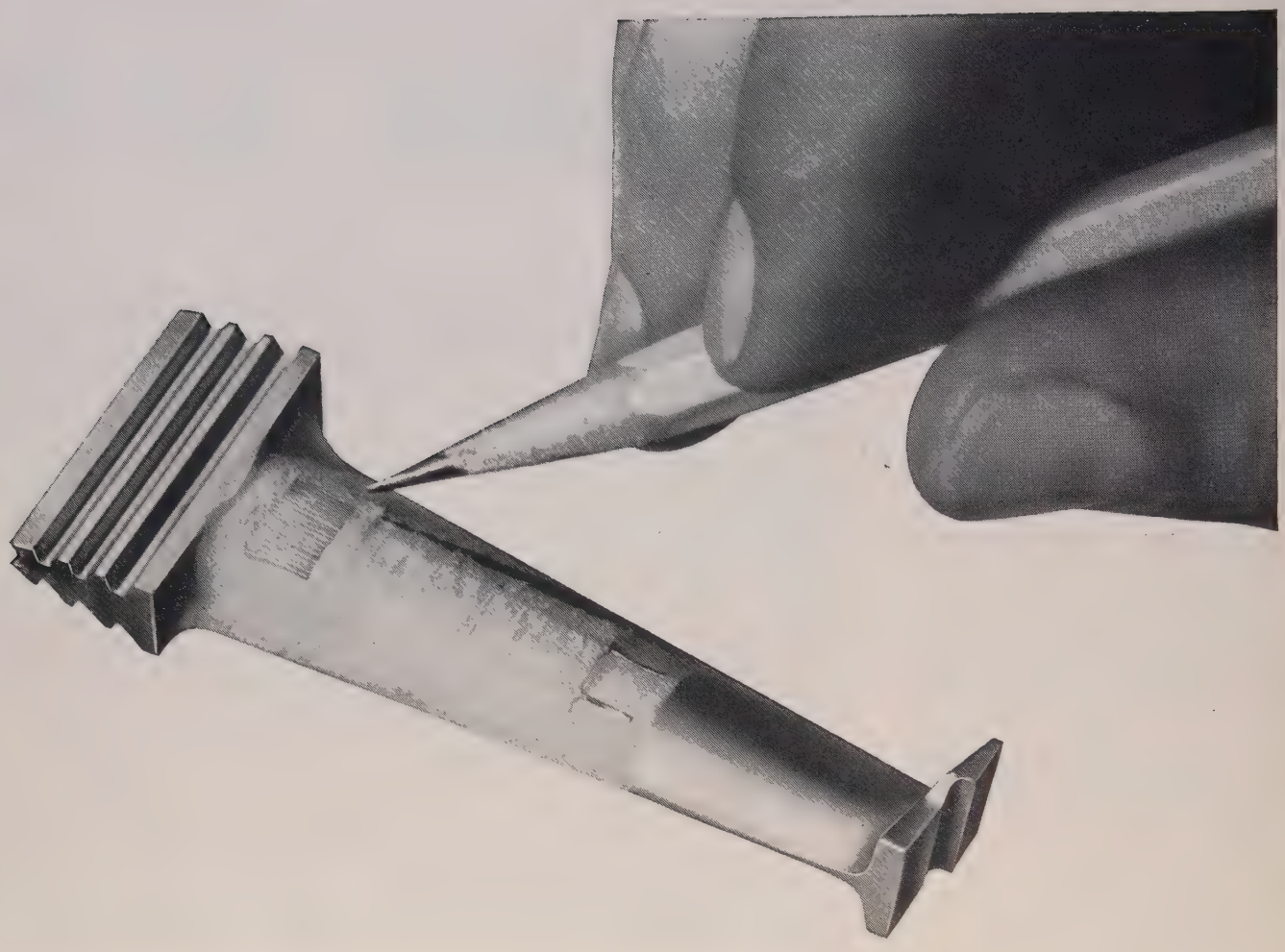
The Mechanical Engineering Department's Open House display of their internal combustion laboratory. Open House guests are watching the power and economy tests of the GMC engine in the internal combustion laboratory. This display tied for second place with the Electrical Engineers' display. Other Mechanical Engineering displays were steam engines, turbines, foundry, and reaction time and stopping distance testers.



OPEN HOUSE . . .

This pan is actually floating on air. The aluminum sauce pan is supported by electromagnetic waves generated under the table. The Electrical Engineering Department's exhibits tied for second place. Other exhibits by the Electrical Engineers were atomic cannon, electronic lecture, illumination lecture, "Kiss-O-Meter," and many other interesting things.

Wayne Barker, junior in Civil Engineering demonstrates stream flow through a culvert. Hydraulic studies on models such as this have resulted in improved drainage structures under highways and railroads. Continuing research has brought about changes in design specifications consistent with modern engineering theory.



important wire on a hot subject . . .

Even at temperatures of 1500° — speeds of 12,000 rpm — this tiny wire grid reports to our engineers on the strains in jet turbine blades. It gives them accurate measurements for calculating stresses caused by resonance and flutter.

This basic information, in turn, permits the design of blades that combine the optimum aerodynamic characteristics with structural integrity.

Strain gages are not new. But our engineers had to advance the art considerably to get readings at these high speeds and temperatures. It required the development of improved cements, instrumentation, slip rings . . . new application techniques and calibration curves.

Nothing can be left to chance in the design of aircraft engines for supersonic flight. Thus we use — and frequently improve on — every advanced technique and engineering tool. This straight-forward approach to engineering problems is one of the reasons many outstanding engineering graduates decide on a career at Pratt & Whitney Aircraft.

PRATT & WHITNEY AIRCRAFT

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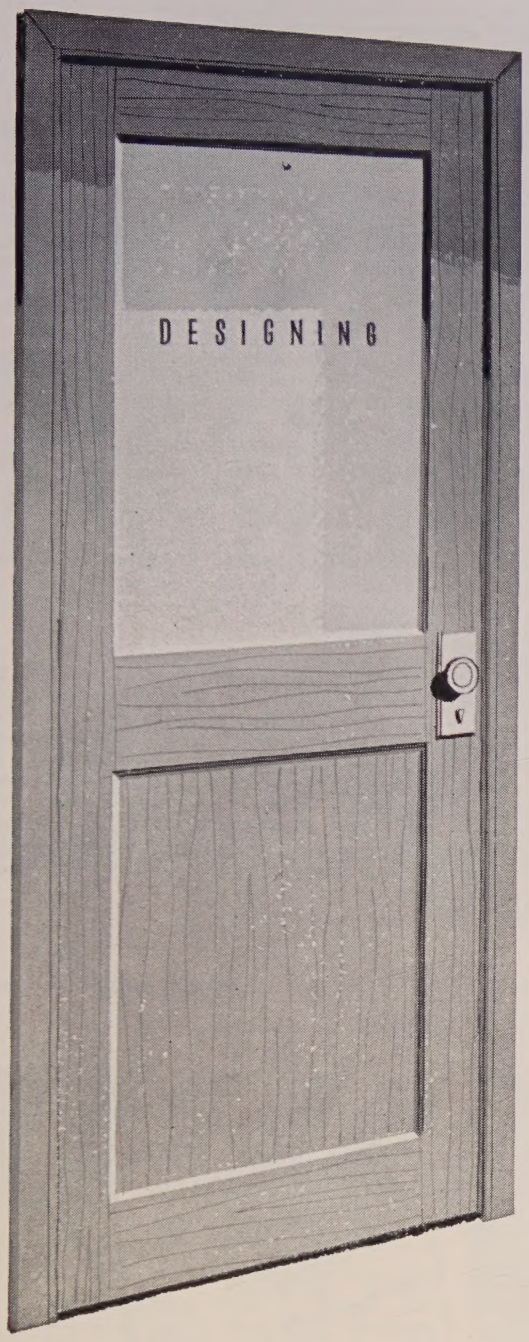


logical way

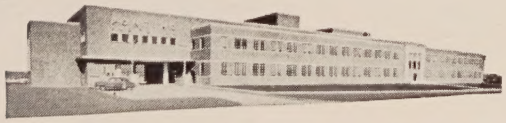
—*to a promising future!*

A RECENT SURVEY shows that many of today's leading engineers and industrial executives walked through this door to start their careers.

In fact, the majority of all leading positions in automobile engineering are held by men whose basic training was in designing—one of the best paths for the young man who wants an engineering career.

And if you want to be an automotive engineer you can't find a better place to start than with Pontiac. Experienced engineers stand ready and anxious to help young men with fresh ideas tackle problems that when solved will mean still finer and more dependable cars. Here's a company you can grow with, a company that offers a future limited only by your own ability.

It's a very logical way to a career based on opportunity and advancement and liberal compensation plus General Motors employment benefits.

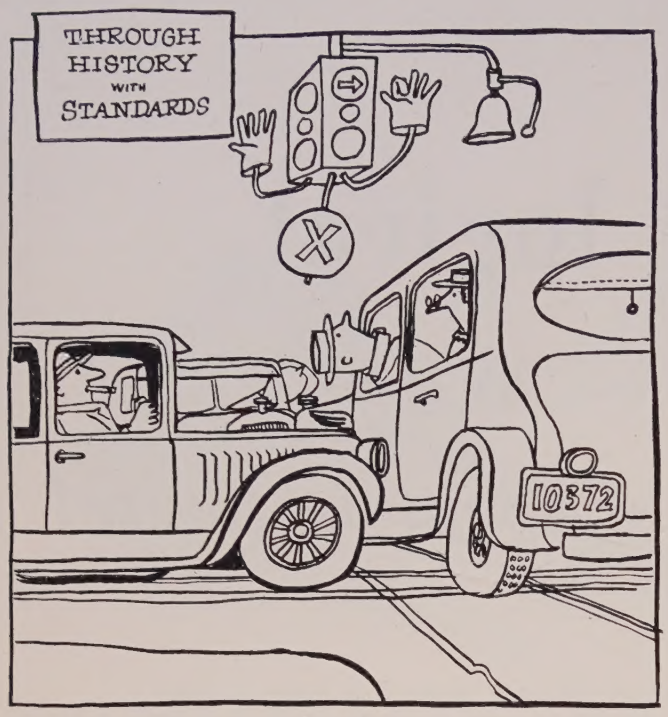


Pontiac's huge new engineering building is one of the industry's most modern—with every conceivable facility for designing better and better Pontiacs.

PONTIAC

MOTOR DIVISION · PONTIAC, MICHIGAN

GENERAL MOTORS CORPORATION



The majority of men slip into their graves without having encountered on their way any signal catastrophe.
ALEXANDER SMITH, Dreamthorp

WHY TRAFFIC SIGNALS WERE A GREAT HAZARD BEFORE THEIR STANDARDIZATION

As late as 1927 a color-blind autoist stood as good a chance as anyone of interpreting traffic signals. For lack of national standardization, he could choose between purple, orange, blue, green, yellow, and red lights for his directions as he drove from state to state. Green, for instance, was "Stop" in some states and "Go" in others. Red, instead of yellow, was the caution signal in New York City.

And a motorist would have to stop his modern low-vision car a block back from the next traffic light in order to see it. Early signal towers often were as high as the second story on business buildings.

These problems have been solved in two national codes—one on colors for traffic signals, and the other on street signs, signals, and markings.

A national code for colors for traffic signals was first formed in 1927 through work of the American Association of State Highway Officials, the National Bureau of Standards, and the National Safety Council. It was approved as an American Standard. It recommended green for "Go" and red for "Stop," now virtually a world standard.

The national code for street traffic signs, signals, and markings was first started in 1927 as an American Standard under the American Engineering Council. In 1935 a joint committee of the American Association of State Highway Officials and the National Conference on Street and Highway Safety drew up a Manual on Uniform Traffic Control Devices based on the prior work of the ASA project. It was approved as an American Standard. A new edition of the manual was begun in 1944 and published in 1948, containing significant revisions to meet present-day traffic conditions. Its recommendations for height of signals and design and color of signs are almost universally followed in this country.

HOW A STANDARD FOR STEAM BOILERS BROUGHT NEW SAFETY TO AN OLD HAZARD

From the earliest practical applications of steam for prime movers in the 18th century, boiler explosions were a serious cause of loss of life and damage to property. Steamboat boiler explosions were especially common, comparing in frequency and severity with the worst catastrohies of today. On April 27, 1865, for instance, the steamboat Sultana, plying the Mississippi River near Memphis, exploded with the loss of 1450 lives.

In 1911 the Council of the American Society of Mechanical Engineers appointed a Committee to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and Their Care in Service (known since 1914 as the Boiler Code Committee). It issued the first ASME Boiler Code three years later.

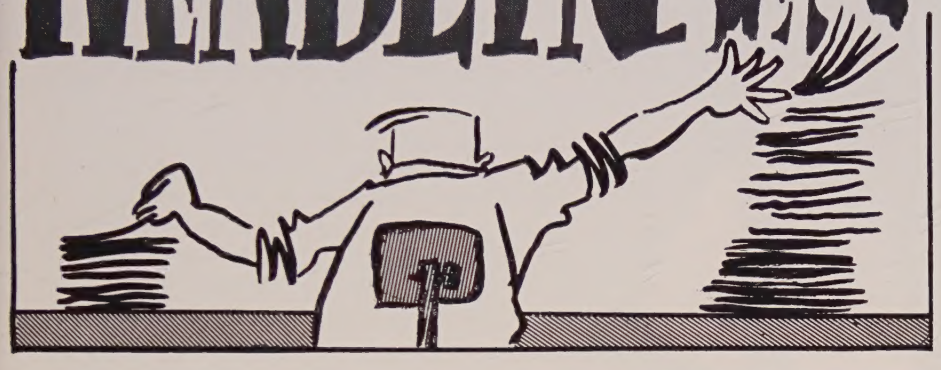
The makers of this code set out to create a set of rules for the construction and care of steam boilers that would be adopted by all the states of the union. Today, 28 states and territories, eight provinces of Canada, Australia, Mexico City, and a number of other countries and cities have adopted one or more sections of the Code. Through its extensive use and uniform administration, the Code is now in every sense of the word a national standard.

The 1952 Code, as revised and enlarged, has nine sections totaling some 1,000 pages. It is administered by a committee of 24 members and an executive committee of eight, made up of men of special training and experience representing designers, fabricators, suppliers of materials, operators, and consultants. Some three dozen subcommittees serve under the Code committee.

Since 1916 the record of serious boiler explosions has been exceptionally low, despite the great increase in the number and size of boilers. For this, the Boiler Code Committee has been in a large measure responsible. In a citation to the committee in September, 1952, the American Standards Association stated: "Probably no other single standard in America has done more for national safety than the ASME Boiler Code."

It shall be a vexation only to understand the report.
IZAIAH, XXVIII

SKIMMING INDUSTRIAL HEADLINES



edited by Larry Kiefling, M.E. '56

Better Photo Film

A remarkable new high speed professional sheet film—Kodak Royal Pan—is available in all sizes. The new film is twice as fast as previous films of this type. The increase in emulsion speed has been achieved, however, without any increase in film graininess.

The development, company officials indicated, represents a significant gain in film emulsion technology, since until the introduction of Kodak Royal Pan film emulsion technologists have been limited to their ability to achieve increases in film speed without accompanying increases in granularity.

The new film is expected to prove of tremendous value to press, commercial, portrait, illustrative, and industrial photographers. Its increased speed will be particularly helpful in these fields since it will permit photographers to make pictures which have heretofore been almost impossible.

The new film has an A. S. A. exposure index of 200 for daylight. The tungsten index is 160.

In addition to its speed the film has been designed to give improved shadow tone contrast or crispness. At the same time the company has been able to incorporate factors in the emulsion which reduce the tendency of highlights to "block up," as is often the case where overexposure or overdevelopment occur.

This reduced blocking characteristic is expected to be of particular help to photographers when the lighting range cannot be carefully controlled, since the resulting negatives can be printed with less shading and dodging. In such instances the greater transparency of the highlight areas also will be helpful in the production of better quality prints from difficult subjects.

This action shot was made on Kodak Royal Pan film at f-4.7, and 1/200th of a second.

By design the new film will tolerate a very wide range of both over and underexposure, and still produce negatives which will make satisfactory prints. To further complement the exposure latitude, the company has also increased the development latitude so that the contrast of the negative will not change as rapidly with small amounts of overdevelopment.

For example, a series of negatives exposed the same time and developed for 4, 5, and 6 minutes might very easily produce equally acceptable prints on the same grade of paper. Even a negative developed as much as 8 minutes requires only one grade of softer paper.

The increased speed of the film will in many instances permit pictures to be made with press type cameras which heretofore could only be made with reflex or miniature cameras having faster lenses. Pictures can also be made under conditions which would previously have been impossible for picture taking with professional sheet film cameras. On the other hand, the new film offers tremendous opportunities for improving the general run of photography because the lens stop can now be set one full stop smaller leading to increased depth of field or range of sharpness, or the shutter speed can be doubled to better stop subject movement.

Still other benefits offered by the new film is improved speed relate to its effectiveness with various types of lighting equipment.

The possibilities for the effective and convenient use of very small flash lamps—such as the No. 8's—are, for example, definitely improved. The faster film also makes portable speedlights the equivalent of being twice as bright, or, looking at it from another way, it opens possibilities for the building of even smaller, lighter weight, units.

Art: "Is your girl spoiled?"
Sam: "No, it's just the perfume she wears."

* * *

"I hear he was a big gun in college."
"That so? What kind?"
"A sort of smooth bore."

* * *

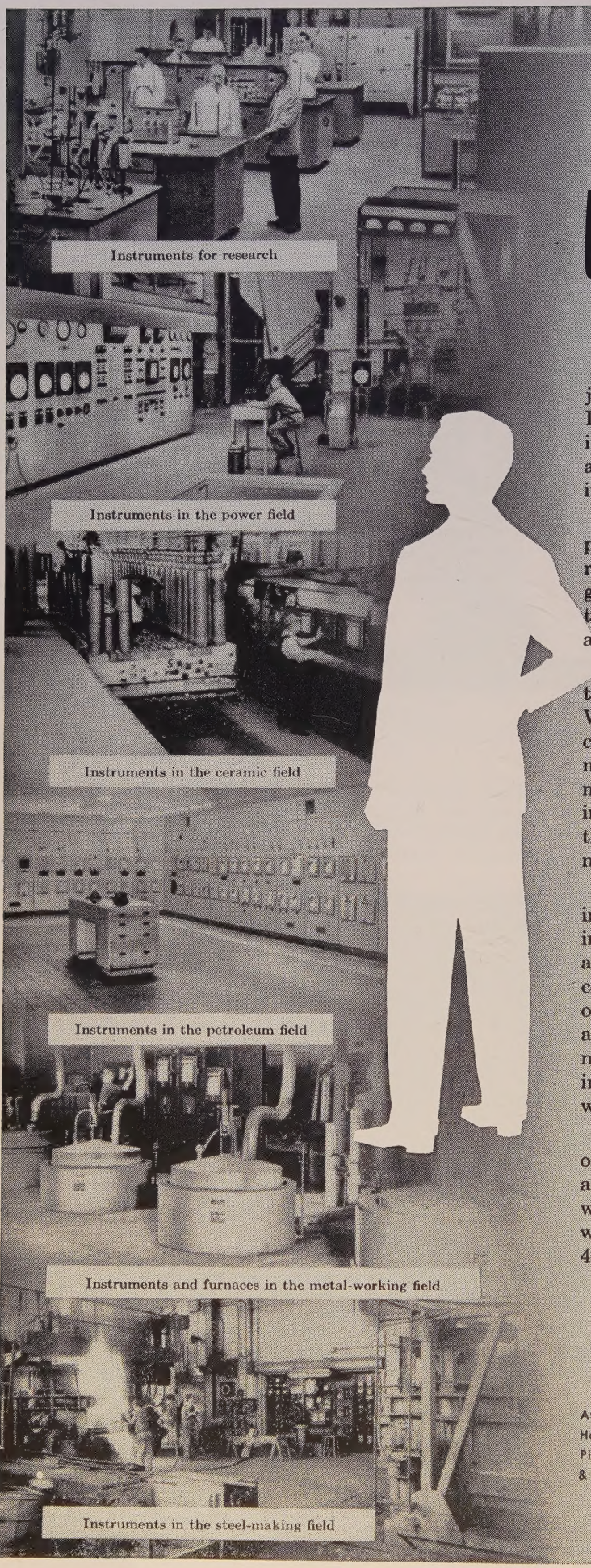
Ed Gardner's friend, Finnegan, was down at Duffy's Tavern enjoying a glass of beer. "How many barrels of beer do you use a day?" he asked the proprietor.

"Four," said the barkeep. "Why do you ask?"

"Cause I can tell you how you could use eight barrels a day."

"You can?" came the delighted response. "How can I?"

"Give full glasses," Finnegan retorted bitterly.


Instruments for research
Instruments in the power field
Instruments in the ceramic field
Instruments in the petroleum field
Instruments and furnaces in the metal-working field
Instruments in the steel-making field

TAKE YOUR PLACE IN A FIELD WITH A FUTURE . . .

Instrumentation

Is there still some question in your mind as to just where you fit into the engineering picture? If there is . . . and you want to apply your ability to a wide scope of industrial and scientific activity . . . consider the expanding field of instrumentation.

The increasing use of instruments to control production lines . . . to test products . . . to solve research problems is reflected in the spectacular growth of the field. In recent years, sales of electrical measuring instruments have risen 455% and sales of scientific instruments 655%.

Here at Leeds & Northrup, we help to meet these demands for more and better instrumentation. We are a leading supplier of automatic, high precision, balance-type electrical instruments for many segments of industry. Our automatic and manual laboratory-type instruments for the worker in science and research are recognized throughout the world. In addition, we are among the leading makers of furnaces for heat treating.

Perhaps your opportunity is in our sales engineering division—helping to analyze and to solve the instrumentation problems of our customers. Or, as a market development engineer, you would be concerned with fitting L&N instruments to new groups of applications. Your interest may lie in the design and manufacturing of L&N products. If so, you may qualify for an opening in product engineering, industrial engineering, research, inspection or elsewhere among our 3000 people.

Decide now to investigate your place in the field of instrumentation. Ask your placement officer for a copy of our booklet, "Career Opportunities" which describes the highlights about L&N. Or, write to the Industrial Relations Department, 4850 Stenton Ave., Philadelphia 44, Pa.

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